


THE NORTH CAROLINA
AGRICULTURAL
EXPERIMENT STATION
1908-1909







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THIRTY-SECOND ANNUAL REPORT

N. C.
Doc

OF THE

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

YEAR ENDING JUNE 30, 1909

INCLUDING SCIENTIFIC PAPERS AND BULLETINS.

Nos. 200, 201, 202, 203, 204

WEST RALEIGH, N. C.

RALEIGH

E. M. UZZELL & Co., STATE PRINTERS AND BINDERS

1911

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
UNDER THE CONTROL OF THE
TRUSTEES OF THE A. AND M. COLLEGE.

GOVERNOR W. W. KITCHIN, *ex officio* Chairman, Raleigh.

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STATION STAFF.

D. H. HILL, President of the College.

C. B. WILLIAMS.....	Director and Agronomist
W. A. WITHERS.....	Chemist
F. L. STEVENS.....	Vegetable Pathologist and Bacteriologist
J. S. JEFFREY.....	Poultryman
F. C. REIMER.....	Horticulturist
R. S. CURTIS.....	Animal Husbandman
JOHN MICHELS.....	Dairy Husbandman
R. I. SMITH.....	Entomologist
G. A. ROBERTS.....	Veterinarian
J. G. HALL.....	Assistant in Plant Diseases
W. C. ETHERIDGE.....	Assistant Agronomist
B. J. RAY.....	Assistant Chemist
A. R. RUSSELL.....	Assistant in Field Experiments
P. L. GAINEX.....	Assistant Bacteriologist
L. R. DETJEN.....	Assistant Horticulturist
F. W. SHERWOOD.....	Assistant Chemist
A. F. BOWEN.....	Bursar
C. P. FRANKLIN.....	Secretary and Stenographer

The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION,
OFFICE OF THE DIRECTOR,
WEST RALEIGH, N. C., June 30, 1909.

To His Excellency, WILLIAM W. KITCHIN,
Governor of North Carolina.

SIR:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1909.

Trusting that this report will prove satisfactory to your Excellency, I am,

Yours very truly,

C. B. WILLIAMS,
Director.

TABLE OF CONTENTS.

	PAGE.
Board of Trustees and Experiment Station Staff.....	2
Letter of Transmittal.....	3
Report of Director and Agronomist.....	7
Report of Chemist.....	17
Report of Biologist.....	20
Report of Poultryman.....	23
Report of Horticulturist.....	26
Report of Animal Husbandman.....	28
Report of Dairy Husbandman.....	31
Report of Entomologist.....	32
Report of Veterinarian.....	34
Financial Statement.....	36
Scientific Papers:	
Effects of Different Fertilizing Materials Upon the Maturity of Cotton.	37
Some Facts Concerning Those Characters of the Corn Plant Associated with Yield and Factors Which Influence Them.....	41
Variation of Fungi Due to Environment.....	47
Carnation Alternariose.....	72
Hypochose of Pomaceous Fruits.....	76
A New Fig Anthracnose (Colletotrichose).....	86
Harlequin Cabbage Bug (<i>Murgantia histrionica</i>).....	90
Is <i>Neocosmospora Vasinfecta</i> (Atk.) Smith, the Perithecial Stage of the Fusarium Which Causes Cowpea Wilt?.....	100
The Scuppernong As a Profitable Crop—Methods of Growing, Keeping, and Wine-making Used At Its Place of Origin.....	117
II—Studies in Soil Bacteriology—Ammonification in Soils and in Solutions.....	119
III—Studies in Soil Bacteriology—Concerning Methods for Determination of Nitrifying and Ammonifying Powers of Soils.....	129
Press Bulletins:	
No. 16—Selecting Seed Corn for Larger Yields.....	145
No. 18—Apple Bitter Rot.....	147
No. 19—Suppression of Terrapin Bugs.....	148
No. 20—Spring Destruction of Terrapin Bugs.....	150

APPENDIX.

BULLETINS:

- No. 200—Feeding Fermented Cotton-seed Meal to Hogs.
- No. 201—Scuppernong and Other Muscadine Grapes—Origin and Importance.
- No. 202—Manufacture and Marketing of Cottage Cheese, Skimmilk-Buttermilk and Ice-cream.
- No. 203—Corn Weevils and Other Grain Insects.
- No. 204—Some Factors Involved in Successful Corn Growing.

THIRTY-SECOND ANNUAL REPORT

OF THE DIRECTOR OF THE

N. C. AGRICULTURAL EXPERIMENT STATION

FOR THE YEAR ENDING JUNE 30, 1909.

BY THE DIRECTOR.

Generally, the work of the Station in all its branches has been increased and actively carried forward by the various workers in a fairly satisfactory manner. Below is given, briefly, something as to the nature and scope of the work which is being conducted by the several Divisions of the Station. This summary is made up from the reports of the different workers and from the observations of the Director.

DIVISION OF AGRONOMY.

The experimental work of this Division has progressed actively along the same general lines as previously reported. Considerable effort has been exerted in the determination of best fertilizer combinations and the most economical quantities of fertilizers to use per acre, especially for cotton and corn. These experiments have shown unmistakably that phosphoric acid is the chief deficiency of our soils here and that potash is the one less needed for maximum yields. The field results have been confirmed by chemical analyses of the soil. The fertilizer formulas used largely by the farmers in the Piedmont section of the State for cotton are not the ones which, judging from our results, afford the greatest profit per acre. The phosphoric acid in them should, as a general thing, be increased, while the potash might be decreased.

The variety tests this year embrace a study of 68 varieties of corn; 42 of cotton; 23 of soy, adzuki and seta beans; 30 of cow-peas; 15 of wheat; 49 of oats, and 4 of clover. In addition to this comparison of varieties with reference to yield, an intimate study is, at the same time, being made of the characters of each variety, with the hope of determining those which are correlated in the different varieties with high yield and superior worth. Variety-distance tests with 68 varieties of corn and 3 of cotton, each of widely different characters, are being conducted to ascertain what distancing of the different varieties produces the best results. From the field seed-selection experiments with corn, cotton, wheat and oats, recently

started, much is expected in the way of improvement and practical scientific information. In the variety test of oats an effort is being made to determine those varieties which are best adapted for fall and spring sowing. Marked differences have developed, not only in yield, but also in earliness and consequent adaptation for different soils and localities and for specific purposes. For sowing in combination with crimson clover or Canada field peas, the earliness in maturity of Burt, Kherson and Culberson varieties especially fits them for this purpose, as they reach the haying stage at practically the same period as do the clover and peas. The white-blooming crimson clover may be used in mixtures with later maturing varieties, such as Red Rust-proof or Appler, as it blooms ten to fourteen days later than the regular crimson clover.

Investigations are being carried on with 68 varieties of corn to determine the factors which operate in the production of suckers on the corn plant and to ascertain the relation which their undisturbed development bears to yield of grain and stover. As these investigations advance, many interesting and economic features present themselves which will shed much light upon the nature of the characters of corn varieties when grown under widely varying conditions of fertilization, distancing and season.

Top-dressing experiments with nitrate of soda and sulphate of ammonia on oats and wheat are being conducted to determine their actual and relative values for this purpose. A comparative study is also being made of different carriers of phosphoric acid and nitrogen for fertilization of cotton and corn.

Many combinations of legumes are being grown to ascertain their relative value for hay and pasturage.

A systematic effort is being made to determine the effects upon percentage of lint to seed, and length and tensile strength of the staple of cotton by allowing the seed cotton to stand exposed for a year to the average conditions prevailing on the farm. This Division is especially fortunate in having under its control considerable land which may be used in making direct application, on a considerable scale, of the facts which are evolved from the carefully planned experiments which are being conducted along different lines. By this means it is felt that a broader conception of agronomical problems in general and their practical solution is obtained.

DIVISION OF CHEMISTRY.

During the year the Chemical Division has sustained intimate co-operative relations with the Biological Division in soil nitrification and ammonification studies and with the Animal Husbandry and Veterinary Divisions in cotton-seed meal toxicity investigations. The preparation of the twenty-two fractions used in the cotton-seed meal feeding experiments with hogs and guinea pigs has largely been per-

formed by the workers of this Division. Much work has been done in connection with these investigations in making chemical determinations of the composition of various feeds, fractions of cotton-seed meal employed in the experiments and of the urine secreted by animals fed on each of these. The Division has been materially strengthened by the addition of an assistant, and, during the first ten months of the year, 3,825 determinations on 1,414 samples have been made. In the bacteriological soil survey of the State which is being carried on this summer co-operatively by this and the Biological Division, the examinations of the Bacteriologist for nitrifying and ammonifying efficiency, nitrifying and ammonifying inoculating power, nitrifying capacity, and bacterial count are being supplemented in each case by a careful chemical determination of the amount of nitrates, nitrites, and ammonia present.

DIVISION OF BIOLOGY.

During the year the research work has been carried forward largely along lines previously begun and reported on. In co-operation with the National Bureau of Plant Industry, this Division in continuation of its Plant Disease Survey of the State has conducted much correspondence with farmers and public-school teachers in order to determine definitely how widespread certain plant diseases are in different localities and to ascertain the amount of damage to crops and fruits they produce. New diseases of the apple, lettuce, clover, tuberoses, fig, carnation, privet, peanut and vetch occurring in the State have been studied and the fungus causing each has been isolated, identified, and described.

The experiments which are being conducted at Auburn on soil badly infected with watermelon wilt will be continued in an effort to secure strains of melons which possess desirable eating and shipping qualities and which may be successfully grown upon soils affected with this disease. The importance of this work cannot be too strongly emphasized, as the melon industry is an important one and in many localities is beginning to be menaced by the appearance and rapid spread of this disease. Melons cannot, to a profitable extent, be grown at present on a badly infected field, and unless wilt-resistant varieties or strains are bred or found, the industry will be wiped out in certain important infected areas of rapidly increasing size.

The tobacco-wilt experiments are this year continued at Creedmoor, which is located in the light tobacco belt of Granville County. Eleven strains of tobacco are being used in the work, and they were put out on badly infected soil. Although there did not develop any marked difference between the ability of the Sumatra, Turkish and Italian types to withstand the wilt, yet the finer qualities of the Sumatras has led to the crossing and use of two strains of this type with the native bright tobacco of the infected section with the hope of securing

wilt-resistant strains of as nearly the same quality as possible as the native bright tobacco. It is planned to devote during the present season about one-fourth of the space allotted to this experiment to a field-study of the resistance and quality of these crosses made last year.

In the lettuce-drop investigations efforts have been directed principally along the line of preventing the formation of sclerotia by the fungus causing this trouble, as it seems to be the only means this disease has of being carried over winter. Should any of the methods devised prove effective against the formation of sclerotia, then the eradication of the disease from infected lettuce-beds seems assured.

The soil bacteriology investigations which this Division is carrying on in co-operation with the Chemical Division have been greatly strengthened by further work and extension. Results secured have brought out rather conclusively the importance of conducting tests to determine the ammonifying and nitrifying powers of soils on the soils themselves, rather than by the use of culture solutions in the usual way, as there seems to be no definite relation whatever between the results on nitrification and ammonification secured on the soil itself and the solution. Methods have been devised for determining fairly accurately the nitrifying and ammonifying power of soils, using the soil as a medium. In marked contrast to the commonly accepted notion that all soils are well supplied with nitrifying organisms, it has been found that 71 per cent of the local soils which have undergone examination have shown very low nitrifying power. The facts have led to the inauguration of a new line of experiments which are designed to study the relative acceptability to plants of nitrate-nitrogen and ammoniacal nitrogen. The experiments are being conducted under complete bacteriological and chemical control. To supplement these, a systematic bacteriological survey of the different soil types of the State has been started, and on each soil determinations of its nitrifying and ammonifying power will be made. Contrary to the accepted idea, results thus far secured seem to indicate very strongly that the presence of organic matter in the soil does not always exert an inhibiting influence upon the activity of nitrifying organisms.

The ptomaine studies which were started last year have been temporarily suspended, due to the absence of suitable material and because of pressure of other investigational work.

DIVISION OF POULTRY.

The operations of the Poultry Division have been to a large extent carried on in the direction of testing various systems of feeding young chicks, managing incubators and brooders and comparing different feeds and combinations for the production of eggs and meat. From the results secured in the cotton-seed meal feeding experiments it

was demonstrated that this material may be fed without detriment to the health of the poultry to the extent of one-fourth of a ration consisting of cotton-seed meal and corn, when the stock is allowed range on grass or other green crops. It will be noticed from results of subsequent experiments that, although the ration containing cotton-seed meal costs less than the ones containing meat and bone meal, yet the latter ones, by inducing earlier development and laying, have produced the cheapest gains in weight and egg production. During the summer it is planned to study the value of skim-milk as a substitute for meat meal and cotton-seed meal.

In the pedigreed breeding experiments for egg production, work has been continued along the same general lines as previously reported. Some of the Barred Plymouth Rock hens used in this work have made a good showing, as also have their pullets. Last year Barred Plymouth pullet No. 7113 laid 143 eggs in seven months. Several daughters of this hen are being used this year in furtherance of the work and studies. The inbreeding work started last year is being continued, but results will not be expected before next season.

In the incubator experiments an effort is being made to determine if it is advisable to artificially supply moisture to and use disinfectants in the incubators before each hatch comes off. In these comparative studies, eggs from the same hens are being used in order to eliminate as far as possible the effects of differences in individuality. Experiments with the fireless brooder have demonstrated that they may be operated successfully, but that the chief drawback to their use is the greater amount of attention which the chicks confined in them require for the first few days.

DIVISION OF HORTICULTURE.

The attention of the Horticulturist has been confined chiefly to preparation for and in a study of "double flower" and self-sterility of blackberries and dewberries with the purpose of determining the nature and cause of these abnormalities. The work was started last year and is now fairly well under way. As 23 varieties of blackberries and 14 varieties of dewberries are embraced in these investigations, it is planned also to make careful observations as to the relative standing of these in reference to earliness and amount and character of fruit. A study will be made at the same time of the influence of many fertilizer carriers and combinations upon yield, "double flower" and self-sterility of the various varieties under experimentation. The careful microscopic study of the doubled flowers and accompanying rosette growth of stems and leaves of the Wilson blackberry and of the character of the flower-parts of the notably self-sterile Premo dewberry, which is being conducted in the laboratory simultaneously with the field work, will doubtless reveal much as to the nature and cause of "double flower" and self-sterility.

Field experiments were begun this spring with eight varieties of dewberries to determine the ability of the several varieties to set fruit without cross-pollination. These were undertaken by enclosing 500 flower clusters in paper bags before the flowers opened. Results thus far secured by the Horticulturist seem to indicate that "double flower" is intimately associated in some way with early dropping of the old leaves during the previous year and to the premature development of buds which would normally produce fruit the succeeding year.

Some preliminary work with figs, Japanese plums, and muscadine grapes has been gotten well under way during the year. A bulletin on the Origin and Importance of the Scuppernong and Other Muscadine Grapes is now in press. This will be followed by study and publication on other features of muscadine grape growing. It is a notable fact that most of the leading varieties of muscadine grapes have been originated in this State.

DIVISION OF ANIMAL HUSBANDRY.

The Animal Husbandman has devoted considerable effort and time in providing new equipment and in getting under way new lines of experimentation. A major portion of his efforts has, however, been given to a careful supervision of the investigations which are being conducted jointly by the Animal Husbandry, Veterinary and Chemical Divisions to determine the cause for the disastrous results which frequently follow the feeding of cotton-seed meal to swine, and to isolate, if possible, the toxic principle, if such it may be. Feeding experiments which have been carried on by other experimenters with cotton-seed meal up to the present have been of an empirical nature, and have afforded information only with reference to the quantity which may be fed, length of the feeding period and the symptoms and post-mortem revelations produced by overfeeding. During the year 28 pigs and 93 guinea pigs have been used in carrying on these investigations. Out of the 23 fractions of cotton-seed meal that have been fed, 7, having proven practically innocuous, have passed from under further experimentation for the present. For comparison with the results secured with feeding cotton-seed meal, linseed meal and blood meal, as highly concentrated proteinaceous feeds, are being fed with the same supplementary feeds and in the same proportions to guinea pigs under control conditions. A series of experiments has recently been started to determine the toxicity of cotton-seed meal when fed in conjunction with corn and green clover leaves to guinea pigs. From the results secured in feeding cotton-seed meal to horses and mules, it is felt that as a supplement to ear corn, shelled corn and corn-and-cob meal, this feed cannot generally be fed in larger quantities than three-quarters to one pound per day and have it eaten clean. When fed in connection with dried brewers' grains or wheat

bran one and one-half pounds were readily eaten. During the course of the experiments it has been observed that horses eat the meal more readily than do the mules.

Experiments are being conducted to determine the value of green crops in general as pasturage for hogs and to further ascertain the relative value of oats, rye, and rape, sown alone and in different combinations. In these experiments cowpeas, peanuts, and sweet potatoes have been used, allowing the hogs to run on them *ad libitum* after the crops have reached almost maturity. By a system of rotation it has been possible to have green crops practically the entire year for the hogs to run on. The results thus far secured from this succession of crops have been quite encouraging. Grading experiments have been started and are well under way with hogs. For this work a pure-blooded Berkshire sire is being used.

During the year a Bulletin on Feeding Fermented Cotton-seed Meal to Hogs has been prepared and issued, and two others are in course of preparation.

Plans are being developed for this Division to feed experimentally this fall a carload of high-grade mountain steers.

DIVISION OF DAIRY HUSBANDRY.

The Dairy Husbandman has, during the year, given much time to working out the details of a commercial method of preparing cottage cheese. A feeding experiment with eight dairy cows has been conducted to determine the relative economy of feeding medium and narrow nutritive rations for milk and cream production under North Carolina conditions. The results of this experiment and of cottage cheese work are now in Bulletin form ready for publication. During the year Bulletins on Handling and Marketing of Milk and Cream and Feeding Experiments with Cows and Calves have been prepared and published.

DIVISION OF ENTOMOLOGY.

Much time of this Division has been devoted to studies of the life-history and habits of the cabbage webworm, harlequin cabbage bug and plum curculio, and during the year two Press Bulletins giving directions for combating the harlequin bug have been prepared by the Entomologist and issued.

The fumigation experiments which have been carried on have demonstrated rather strikingly the unreliability of carbon bisulphide as a remedy against corn weevils in the average corn bin, especially when used in the quantities generally recommended per thousand cubic feet. Otherwise following the commonly given directions in using this agent, but employing twenty times the quantity generally recommended, it was found that it was not effective when used even in

this quantity in the Station barn as a destroyer of weevils. Sulphur fumes were tried and were found satisfactory so far as killing the weevil was concerned, but cannot be recommended for general use, as the fumes materially reduce the germinating power of corn thus treated. The plum and apple trees at the Poultry farm which became badly infested with San José scale have almost been freed from it by systematic spraying. The apple trees belonging to the Station have also been kept quite free from the ravages of codling moth by two sprayings, just before the trees bloom, with Bordeaux mixture containing three pounds of arsenate of lead to fifty gallons of the mixture.

An insect collection, representing all the beneficial and injurious forms occurring in the State, with records of dates and places of occurrence, is gradually being brought together.

DIVISION OF VETERINARY SCIENCE.

The time of this new Division has largely been taken up in aiding in carrying forward the cotton-seed meal feeding investigations which the Division is conducting jointly with the Animal Husbandry and Chemical Divisions. The Veterinarian has made daily observations and kept records of the weight, temperature, pulsation and respiration of a good many of the hogs and guinea pigs which are being employed to further the investigations. A study in many cases is being made of the blood which is diseased by prolonged cotton-seed meal feeding. All animals dying have been subjected to post-mortem examination and all revelations as to internal derangement were carefully noted. In many instances diseased tissues were preserved for subsequent microscopic examination and study.

In co-operation with the Biological Division, this Division has done some work along the line of inoculating milk with dirt and germs from different sources to determine if such milk after a sufficient lapse of time would produce ptomaine poisoning when injections of it were made into guinea pigs. Some work has been carried on during the year to determine the value of a recently discovered serum as an effective preventive against hog cholera and to determine the relative worth of turpentine and thymol as vermifugal agents for hogs infested with worms.

POLICY OF THE STATION.

It would appear that the Station can best subserve the purposes of its creation by confining its efforts as largely as possible to investigational work along a few lines which have been carefully planned, with a clear conception of the ends to be attained, by strong and specially

equipped men of experience who are broad, painstaking, inventive, resourceful and are not afraid to work and who can distinguish between truth and opinion and between fact and theory. To a large extent, agricultural education, which is making such rapid progress in these latter days, is largely limited in its development by the advances made by the Experiment Stations in supplying material of a fundamental nature for teaching purposes. The Station, under the provisions of the Adams Act, has resources for carrying on research work of an original and fundamental nature in agriculture.

An effort is being made to have all work of an investigational nature so planned and conducted that the results secured will not only have scientific worth, but will also have direct economic value. Although it has no direct bearing on investigations under way, some attention has been devoted to an improvement in the appearance of the grounds, buildings and general surroundings, because it is felt that the manner in which the general operations of the Station are conducted will be a potent factor in determining the local standing and influence of the Station, if not more.

NEW BARN AND SILO.

During the year a new up-to-date gambrel-roof barn has been finished. It is 100 feet long and 42 feet wide and has haymow space for holding something like 150 tons of forage. It is ideally located, well lighted and ventilated and is provided with roomy granaries, with stalls and driveways and sliding doors at all openings. At the east end of the building a large end haymow door is arranged with flexible wire cable, pulleys and weights, and is made to slide in guides on the exterior of the building. Hay trackage and carrier run the full length of the barn.

At the west end of the barn a stave silo, of 130-ton capacity, is conveniently located both for filling and feeding from. The design and arrangements of the barn specially fit it for use in feeding beef cattle.

BULLETINS.

Bulletins have been issued during the year as follows:

No. 200—*Feeding Fermented Cotton-seed Meal to Hogs*, by R. S. Curtis.

No. 201—*Origin and Importance of the Scuppernong and Other Muscadine Grapes*, by F. C. Reimer.

No. 202—*Manufacture and Marketing of Cottage Cheese, Skim-milk-Buttermilk and Ice-cream*, by John Michels.

No. 203—*Corn Weevils and Other Grain Insects*, by R. I. Smith.

No. 204—*Some Factors Involved in Successful Corn Growing*, by C. B. Williams.

No. 16 (Press Bulletin)—*Selecting Seed Corn for Larger Yields*, by C. B. Williams.

No. 18 (Press Bulletin)—*The Apple Bitter Rot*, by F. L. Stevens.

No. 19 (Press Bulletin)—*Suppression of Terrapin Bug*, by R. I. Smith.

No. 20 (Press Bulletin)—*Spring Destruction of Terrapin Bugs*, by R. I. Smith.

The reports of the heads of the several Divisions, financial statement, and scientific papers follow.

REPORT OF CHEMIST.

During the year ended June 30, the Chemical Division has been engaged mainly in investigations relating to nitrogen metabolism in soil and the toxicity of cotton-seed meal.

The investigation relating to soil bacteriology has been conducted in co-operation with the Division of Bacteriology. The analytical portion of that work has involved 5,606 determinations in 1,579 samples of soil and 526 solutions, as follows:

Nitrogen as ammonia by magnesium oxide.....	1,030
Nitrogen as ammonia by sodium hydroxide.....	240
Nitrogen as nitrates colorimetrically.....	107
Nitrogen as nitrates Tiemann-Schulze.....	1,529
Nitrogen as nitrites Griess.....	1,446
Nitrogen as nitrites and nitrates, Diphenylamine.....	1,190
Nitrogen total by Kjeldahl.....	20
Nitrogen total by Kjeldahl and Nessler.....	44
	<hr/>
	5,606

Three articles have been prepared representing the results of this work. The first was published in the report of the Station for 1908-09, and in the *Centralblatt fuer Bakt.* XXIII, 355-373. The second and third articles have been published by the same journal and are submitted for publication with this report. An article on the work was published in *Science*, March 26, 1909, and a report of article three was made to the North Carolina Academy of Science at its May meeting. A fuller account of the work is shown in the report of the Bacteriologist.

The investigation relating to the toxicity of cotton-seed meal has been conducted in co-operation with the Animal Husbandry and Veterinary Divisions. The analytical portion of this work has involved 60 determinations in 19 samples of cotton-seed meal, and 495 determinations in 129 samples of pig and guinea-pig urine, as follows:

Albumin	129
Nitrogen by Kjeldahl.....	13
Nitrogen by ureometer.....	95
Specific gravity	129
Sugar	129
	<hr/>
	495
Ash	3
Betain	1
Choline	1
Crude fiber	2
Extract by carbon tetrachloride.....	2
Extract by ether.....	4
Extracts by six other solvents.....	8

Moisture	5
Nitrogen	32
Pentosans	1
Raffinose	1
	<hr/>
	60

The feeds for the guinea pigs have been prepared mainly by the Chemical Division and the work so far has been planned mainly by the Division. Fractions of the meal obtained by the use of various solvents have been fed to guinea pigs, and several of these feeds have been found to be nontoxic. The toxic portions are still being fractioned and fed.

The miscellaneous work of the Division has consisted of 72 determinations in 41 samples. The samples were as follows:

Boiler scale	1
Feeding stuffs	18
Fertilizing materials	8
Marls	6
Minerals	3
Soils	4
Urine	1
	<hr/>
	41

The 72 determinations in the 41 miscellaneous samples were as follows:

Calcium oxide	9
Carbon dioxide	8
Gold	1
Moisture	4
Nitrogen as ammonia by magnesium oxide.....	1
Nitrogen as nitrites.....	1
Nitrogen as nitrates.....	1
Nitrogen total	13
Phosphorus pentoxide	9
Potassium oxide	4
Sulphur dioxide	13
Acidity	3
Ether extract	4
Humus	1
	<hr/>
	72

The grand total of work for the year was 6,233 determinations in 2,294 samples.

During the past year the chief of the Division was elected vice president of the Association of Official Agricultural Chemists, and, in addition to the publications referred to, has published an article in the *Student Farmer*, *The Progressive Farmer*, and the *News and Observer* upon the importance of the substitution of horse power for human power in agriculture in North Carolina.

Dr. W. A. Syme was appointed State Oil Chemist, and has tendered his resignation, to take effect May 1. I am glad to bear witness to his ability, skill, high character and pleasant personality.

J. K. Plummer was added to the staff of the Division on August 15, and has proven a very rapid and satisfactory worker. He will leave his work here on September 1 to accept a scholarship and pursue post-graduate work at Cornell University. F. W. Sherwood was added to the staff of the Division on May 1, and Hubert Hill has assisted with the work from time to time.

The Division needs more commodious quarters, which I trust will be provided in the new building.

I wish to express my appreciation of the faithful work by the assistants in the Division and to thank you for your cordial co-operation and interest.

Very respectfully,

W. A. WITHERS,
Chemist.

REPORT OF BIOLOGIST.

I hereby submit a report of the Division under my charge for the fiscal year now closing.

The following completed articles represent experiments completed and conclusions reached by work of this Division:

Concerning Apple Diseases.

Hypochnose of Pomaceous Fruits.

Soil Bacteriology (in Co-operation with the Division of Chemistry).

II. Studies in Soil Bacteriology.

Ammonification in Soils and in Solutions.

Concerning the Existence of Non-nitrifying Soils.

Miscellaneous Plant Diseases.

A New Fig Anthrachnose, Colletotrichose.

Alternariose of the Carnation.

Variation of Fungi Due to Environment.

An examination was made of three samples of corn meal received from Wilmington, N. C., which were suspected of bearing a causal relation to pellagra, several cases of which had occurred in that vicinity recently, and a report was made concerning the more common species of fungi which were found therein.

One Press Bulletin, No. 18, *Apple Bitter Rot*, has been issued.

INCOMPLETE WORK.

In addition to the above work which may be regarded as completed, much other new work is under way.

Apple Diseases.—Several interesting apple diseases, some of them new, are still the subject of study.

Lettuce Experiments.—Work on lettuce sclerotiniase has been continued, following the suggestions indicated by our previous studies, which showed that hibernation of the fungus seems to be limited to the sclerotia. The lettuce bed was last year thoroughly infected with the disease. Our efforts this year have been entirely directed to the prevention of the formation of sclerotia, with the hope that within a year or two we may be able to demonstrate the possibility of completely eradicating the disease from an infected bed. Also an undescribed lettuce disease of very great destructiveness has been brought to our attention from Fayetteville and elsewhere. The bacteria causing this disease has been isolated. Artificial infection has been produced and we are now determining the identity of the organism, its relationship and its characters.

Sclerotinia on Clover.—A very serious clover disease caused by

this fungus, close kin to that on the lettuce, has come to the laboratory. The causal fungus has been isolated and successful inoculations made.

Soil Bacteriology.—This work is being conducted jointly by the Biological and the Chemical Divisions. At present two main lines are under investigation, as follows:

1. Methods for the determination of Nitrification and Ammonification. This work embraces a trial of the efficiency of various methods to determine these factors.

2. Ammoniacal Nitrogen versus Nitrate Nitrogen. The fact that many of our soils are deficient in nitrifying power has raised the question whether nitrates are of great importance to plants or whether ammoniacal nitrogen may not be fully as acceptable to plants as nitrate nitrogen. To test this question, numerous experiments are under way under full chemical and bacteriological control.

BACTERIOLOGICAL SOIL SURVEY.

In order to ascertain whether the deficiency in nitrifying power, so marked in the neighborhood of Raleigh, is general throughout the State, it is planned to receive numerous samples of typical soils from all portions of the State and to determine their ammonifying and nitrifying powers, employing the methods devised by us and which are mentioned above.

In addition to the above major investigation, several other interesting observations have been made. For example, a serious outbreak of the *egg-plant wilt*; the occurrence of a very serious *maple-leaf disease* in Raleigh which seems to be due to a yeast; the occurrence of a *cotton-leaf spot* due to a species of *Phyllosticta*, possibly new; a very serious, widely spread, *sweet-potato disease*, possibly due to *Oospora*, which seems always to be present; the occurrence of the alga-like fungus *Rhodochytrium*, which seems to be everywhere on ragweed, though never collected on this plant heretofore and collected only once before in North America and only twice in the world.

Other interesting diseases which have come under our observation are a *fig rust*; a *privet disease* due to fungus attack upon the roots, resulting fatally to the plants; a peanut *Cercospora*, which is quite destructive; a *vetch Colletotrichum*, which seems to be new, and a *rot of tuberose bulbs*, which caused the loss of about 200,000 bulbs to one grower. This last disease has been found to be due to a species of *Penicillium*.

MELON AND TOBACCO WILTS.

Work has been continued on the lines of preceding years, looking to control of the melon and the tobacco wilts through the development of resistant varieties.

PLANT-DISEASE SURVEY.

This work is carried on in co-operation with the National Bureau of Plant Industry. Hundreds of letters have been sent to farmers throughout the State, in order to ascertain the prevalence of certain diseases of plants and to secure information concerning their distribution. The results of this work will be summarized and published later.

Several identifications of seeds, weeds and fungi have been made and a few bacteriological water examinations have been completed.

CORRESPONDENCE.

Numerous inquiries concerning plant diseases and other botanical questions have been received and answered. In all, several thousand pieces of mail matter have been sent out by this Division.

During the year, J. C. Temple, assistant in Soil Bacteriology, a most efficient worker, has resigned to assume charge of the Department of Soil Bacteriology at the Georgia Experiment Station, and has been succeeded by P. L. Gainey, who is doing able and conscientious work.

Respectfully submitted,

F. L. STEVENS,
Biologist.

REPORT OF POULTRYMAN.

I beg to submit the following report of the work in the Poultry Division for the year ending June 30:

During the year experiments have been conducted in feeding for profitable egg production, in breeding for increased egg yield, in determining the advisability of supplying moisture in incubators and of disinfecting incubators before each hatch. The studies in in- and line-breeding have been continued.

FEEDING EXPERIMENTS.

Feeding work this year has been largely along the line of comparing cotton-seed meal and meat meal as sources of protein for laying hens.

When this work was started during the summer of 1908 it was not known what effect cotton-seed meal would have on the health of the hens. All that was known was that for some of the larger animals it is a valuable feed, while for others it cannot be fed except in small quantities and for limited periods without detriment to the health of the animals.

In order to test this, it was fed to several pens of fowls for three months in quantities ranging from 10 to 20 per cent of the total ration. No bad effects to the health of the fowls resulted from feeding any of the rations.

On December 1st fourteen pens of fowls were used to continue this work; five of these were fed rations which contained cotton-seed meal; and nine on rations containing meat meal.

The meat meal used was much richer in protein than is usually found in products of this class, as analyses showed it to contain 86 per cent protein and 7 per cent fat. It was, however, deficient in ash when compared with animal meal and beef scrap, which are commonly used in poultry feeding. These latter feeds contain more or less bone, which supplies the ash.

It had been thought that part of the benefit resulting from the feeding of protein from an animal source was due to the mineral matter generally found in these products, and as this element was lacking in the meat meal used, we added bone meal to some of the rations containing both meat meal and cotton-seed meal. Although these experiments have not been completed, it might be well to mention some of the points that the results seem thus far to indicate:

1. Fowls do not relish cotton-seed meal as well as meat meal, and therefore do not eat freely of mash containing cotton-seed meal.
2. Pullets fed on a cotton-seed meal ration do not develop as rapidly or start to lay as soon as those fed on a ration containing meat meal.

3. Hens have done better than pullets on rations containing cotton-seed meal.

4. The addition of bone meal to a meat-meal ration reduced the cost of egg production and increased the size of stock.

5. The addition of bone meal to cotton-seed meal ration did not reduce the cost of production, due probably to the small amount of cotton-seed meal mash eaten.

The results obtained even from the best rations show that if the farmer is to secure the greatest profit from his hens he must take full advantage of his ability to give his hens a good range on a green crop from which they can obtain a large part of their food at very small cost.

In order to determine if the farmer can profitably feed the more concentrated and higher priced feeds, such as meat meal and beef scrap, and, if so, in what proportion and at what time of the year, we propose to put out several pens of fowls on free range, so that different rations can be tested under conditions similar to what the farmer has.

BREEDING FOR INCREASED EGG PRODUCTION.

In this work the progress made has not been as great as had been hoped for. The plan generally recommended for the improvement of both animals and plants, of repeatedly selecting the best producers to breed from, does not appear to give as good results in egg production as in some other lines of work. In a great majority of cases it has been found that the daughters of our best layers are among the poorest layers. In three years' work along this line only one female has been found which has shown any marked power to transmit good laying qualities to her offspring. Neither this hen nor her daughters have been the heaviest layers of the flock, but better average results have been secured from this family than from any other.

From our experience it has been found that it is more necessary to know the breeding quality of our hens than their capacity to make a large yearly record, and that the best progress will be made by selecting individual proved breeders, and through the individual establishing families, rather than by a continued selection of the heaviest layers of indiscriminate breeding.

INBREEDING.

The work in inbreeding, as outlined in last year's report, has been continued. Five pullets from one of the best hens were selected from last year's breeding. Two of these were mated with their own sire, two with a cock of the same line of breeding, but not closely related, and one with a cock of an entirely different line of breeding.

INCUBATION.

The work started last year in testing the value of supplying moisture to the incubator and in disinfecting each incubator just before putting in eggs has been continued.

Disinfecting the eggs with a 10 per cent solution of zenoleum has also been tried. This solution was found to be too strong, as it injured the hatching quality of the eggs.

The use of a sand tray in the bottom of the incubator to supply moisture has given good results, the percentage of chicks which died in the shell being materially reduced. Some incubator operators have questioned the value of this method of supplying moisture in machines when the ventilation is from the top downward. By the use of hygrometers we found that the use of the sand tray raised the relative humidity an average about 10 per cent above that of similar machines in the same room without the sand tray.

Added moisture and disinfection are now being used in the general hatching work of the Station, and it is believed that the disinfection can be extended to the brooder as well with good results.

BROODING.

Both the fireless and heated brooders have been used with good results.

Good, strong, vigorous chickens can be raised in brooders without artificial heat, but for the first week they need more attention than do those reared in the heated brooder. Chicks do not learn to go back into the fireless brooder as quickly as they do in the heated ones, and if left to themselves are apt to stay outside and become chilled. On account of this extra care there is not so much saving in labor as some claim, but there is a very great saving in the cost of equipment necessary to raise the chicks in the fireless brooder, as any handyman can make the necessary box in a few minutes.

GENERAL WORK.

The demand for improved stock for breeding purposes and eggs for hatching continues to increase, this demand being about one-third greater than during the previous year.

The increased price of poultry and eggs, together with the awakening of the farmers to the fact that it pays to keep good stock, are largely responsible for this.

Along with this desire for better stock has come a demand for information as to the care and management of poultry, which has largely increased the correspondence of this Division.

Respectfully submitted,

J. S. JEFFREY,
Poultryman.

REPORT OF HORTICULTURIST.

The following is a report of the work of the Horticulturist for the year ending June 30:

DOUBLE FLOWER OF BLACKBERRY AND OF DEWBERRY.

Work on double flower or rosette has consumed most of the time of the Horticulturist during the year. A preliminary study of the trouble was made during the summers of 1907 and of 1908. The experimental work was started during the past spring.

Only a small amount of the double flower appeared in the Wilson blackberry plat this spring; this was expected, as the trouble is usually not very common until the plants are two or three years old. No double flower has appeared in the Lucretia dewberry plat.

During the spring, observations were made on 23 varieties of blackberries and on 14 varieties of dewberries. A careful study is also being made of the structure of the double flowers, including the rosette-like growth of the stems and leaves and also of the flowers themselves. The double flower, so far as has been observed, never produces any fruit. Many of the stamens are defective and the ovules and druplets do not develop. This work will be extended and continued during the coming year.

During June of the present season experiments were begun to determine what effect spraying, pruning, and picking off the leaves would have on the development of double flower.

SELF-STERILITY IN DEWBERRIES AND IN BLACKBERRIES.

The experimental part of this work was started this spring. About 500 flower clusters of different varieties of dewberries were covered with paper bags to determine what varieties will set fruit without cross-pollination. We are confining ourselves this year to the following eight varieties of dewberries: Austin, Chestnut, Cox, Manatee, Premo, Rogers, San Jacinto, and White. Some interesting and very decided results were obtained during the spring. This work will be continued.

A careful study will be made of the character of the flowers of the Premo dewberry, which seems to be notably self-sterile. This is to determine what really is responsible for the self-sterility, whether it is due to defective stamens or defective unfertile pollen or whether the pollen matures at the wrong time.

The Horticulturist recently published a Bulletin on the Origin and Importance of the Scuppernong and Other Muscadine Grapes. This publication has aroused much interest in this subject.

WORK WITH PLUMS.

Work was started during the spring to determine whether brown rot can be controlled in Japanese plums by thinning the fruit and spraying with the self-boiled lime-sulphur mixture.

Respectfully submitted,

F. C. REIMER,
Horticulturist.

REPORT OF ANIMAL HUSBANDMAN.

I beg to submit the following report of the work carried on by the Animal Husbandry Division for the year ending June 30:

The experiment designed to determine the value of fermented cotton-seed meal for hogs has been completed and the results have been reported in Bulletin 200, Feeding Fermented Cotton-seed Meal to Hogs. The experiment is summarized as follows:

Corn alone proved to be an undesirable ration for growing hogs, causing small gains and unthrift. This condition was more marked, owing to the fact that the lot was closely penned, without pasture; yet the other lots, similarly confined, made relatively larger gains.

Fermented cotton-seed meal can be fed in small quantities for limited periods with good results. The results indicate that seventy-five to ninety days is the limit of satisfactory feeding. This would depend, however, on the age and condition of the hogs, the supplementary feeds, and the proportion of cotton-seed meal fed.

Lot 3, fed a combination of corn and cotton-seed meal, in the proportion of four to one, made larger and cheaper gains for the first ninety days than the lot similarly fed on corn and linseed meal. This would seem to indicate that, when possible, cotton-seed meal should be used, since it contains a larger percentage of protein and sells for about one-fourth less per ton than linseed meal.

Farmers would, according to the results of this experiment, be safe in feeding fermented cotton-seed meal to 75-pound shoats in quantities ranging from one-sixth to one-fifth the total ration, by weight, for a period of seventy-five to ninety days.

The feeding of the four lots of hogs during the first period was more profitable when one part of cotton-seed meal was added to the ration of four parts corn than when corn alone or corn and linseed meal in combination were fed. In the case of linseed meal, however, the greater cost of gain was due to the high price of the feed, and not so much to its lack of efficiency in making gains. Barring this one factor and the possible danger in feeding cotton-seed meal, the two feeds, according to the results of this experiment, are approximately the same in feeding value when fed for the time stated.

With corn and cotton-seed meal each costing approximately \$28 per ton, the results show clearly in favor of the combined corn and cotton-seed meal ration, considering always the limitations given as to the amount fed and length of feeding period. While Lots 2, 3 and 4 had a somewhat larger ration than Lot 1, the larger gains during the first period were sufficient to considerably overbalance this factor.

The practical application of these results would not be to feed under the conditions here described, but rather to feed the corn and cotton-seed meal in connection with grazing crops, which can be produced so abundantly by North Carolina farmers.

When fed with judgment, cotton-seed meal can be made a valuable adjunct to corn as a ration for hogs. It is the cheapest commercial concentrate for the Southern farmer and hence should not be entirely ignored in swine production.

An experiment to determine the value of cotton-seed meal as a feed for horses and mules is in progress. In this it is designed to determine the following:

1. The possibility of using cotton-seed meal as a supplementary feed to corn for work horses and mules.
2. The amounts and conditions under which it could be most satisfactorily fed.
3. The economy of the ration.
4. The effect on the health and condition of the animal.

The experiment was started April 6, 1908, and the meal has been fed continuously to the present. The results secured indicate that cotton-seed meal can be made a valuable adjunct to the ordinary ration for horses and mules, when fed properly. From 1 to 1½ pounds per animal per day have been fed with apparent satisfaction. The meal is most satisfactorily fed, however, when thoroughly incorporated with corn and cob meal, bran, brewers' grain, or some other feed of like consistency. It is not possible to feed the meal in conjunction with ear-corn with satisfaction. To feed cotton-seed meal satisfactorily the feed which forms the basis of the ration should be of such a nature as to permit of the meal being mixed with it thoroughly.

Close observations made on the work-stock, both in the barn and in the field, have revealed no apparent harmful results. This experiment will be continued to study other phases of the problem.

At the beginning of the year an investigation was started to determine the cause of the harmful effects noted when cotton-seed meal is fed to hogs and to isolate the toxin, if such it is.

This work is being carried on jointly by the Animal Husbandry, Veterinary and Chemical Divisions. Hogs and guinea pigs are being used in the work. The use of guinea pigs makes it possible to use in the investigations various parts of cotton-seed meal prepared chemically, which would not be feasible were large hogs used exclusively. Although definite results cannot be given at this time, the work is progressing satisfactorily. The work has gradually increased, as new phases of the work developed.

Along with this work, grazing experiments with swine are being conducted to determine the value of the many forage crops that grow

well in North Carolina. The principal crops used so far are cow-peas, soy beans, crimson clover, sweet potatoes, peanuts, rape, Canada field peas, oats, and rye.

During the year a comparatively large number of inquiries have come to the Animal Husbandman regarding feeding, breeding, and management of live stock.

On the Station farm a number of improvements have been made. The equipment for carrying on the swine experiments is fairly complete. Additional farrowing pens, colony houses, a dipping tank, and pastures have been provided.

Respectfully submitted,

R. S. CURTIS,
Animal Husbandman.

REPORT OF DAIRY HUSBANDMAN.

The main work in this Division consisted of a study of the relative economy of narrow and medium rations for cows under North Carolina conditions. This work was prompted by the relative cheapness of cotton-seed meal, which suggested the wisdom of feeding larger quantities of this material than has hitherto been the custom. Cotton-seed meal is very rich in protein, and rations containing a large amount of it will have a very narrow nutritive ratio—much narrower than is ordinarily recommended for cattle feeding.

The narrow ration fed consisted of five parts cotton-seed meal, four parts wheat bran, three parts corn meal and 50 pounds of corn silage. This ration had a nutritive ratio of 1:4. The medium ration was the same as the narrow, except that $2\frac{1}{2}$ pounds of cotton-seed meal were replaced by $2\frac{1}{2}$ pounds of corn meal, giving this ration a nutritive ratio of 1:5.7.

The results of this experiment were strongly in favor of the narrow ration, but it was thought best to duplicate the experiment in order to allow more positive conclusions to be drawn with reference to the wisdom and practicability of feeding a narrow ration.

The duplicate of the above experiment is now in progress.

A Bulletin on the Manufacture and Marketing of Cottage Cheese, Skimmilk-Buttermilk and Ice-cream was published during the year.

The facilities of the Dairy Division are excellent for the prosecution of effective Station work next year, and five new lines of investigations are already in progress.

Respectfully submitted,

JOHN MICHELS,
Dairy Husbandman.

REPORT OF ENTOMOLOGIST.

The following is a brief statement of the work of the Entomological Division for the year ending June 30:

An investigation of the life-history and habits of the harlequin cabbage bug (terrapiu bug), *Murgantia histrionica*, commenced in April, 1908, and was continued throughout most of the year. (A full account of this investigation, together with remedial suggestions, will be found among the Scientific Papers in this Annual Report, under the headings, "Suppression of Terrapiu Bugs" and "Spring Destruction of Terrapiu Bugs.")

Some attention has been given to a study of the life-history of the cabbage webworm, *Hellula undalis*.

The common little red-house ant, *Monomorium pharaonis*, became very abundant last August in the agricultural building, and an attempt was made to eradicate them, or at least to devise some means of preventing their presence in undesirable places. For nearly four weeks this work was continued with partial success, by collecting thousands of the ants on sweetened baits and by attempting to attract them to poison mixtures. The sweetened baits served to trap thousands of ants, but the poison baits were of little if any value.

It was demonstrated that ants may be kept off laboratory tables, desks, shelves, etc., by the use of a saturated solution of bichloride of mercury, one application being effective for several weeks, except for an occasional stray individual. Any tape, made by soaking strips of cotton cloth in the solution, may be tied around the legs of tables, chairs, etc., and serves to repel the ants for a considerable time.

The corn weevil problem, mentioned in my last report, has been conducted mainly along the line of fumigation. Some field observations have shown that corn may become infested as early as August, while standing in the field. The fumigation experiments have shown that the usually recommended remedy, carbon bisulphide, is not effective under ordinary farm conditions.

The fumes of burning sulphur were tested in the spring of 1908 and again during the past winter. The results proved this to be an effective remedy for killing corn weevils, but it was found to be impractical because it affected the germinating power of the corn; even a smaller amount of sulphur fumes than was necessary to kill the weevils materially reduced the germination of the corn.

Some work was carried on during February with good results in combating San José scale by means of the lime-sulphur wash. The orchard in which the studies were made, as it was badly infested, serves as a good illustration of the benefit derived from thorough spraying with this wash. The apple crop this season has been large

and has been kept quite free from codling-moth worms, *Carpocapsa pomonella*, by two sprayings just after the blooming period with a mixture of 3 pounds of arsenate of lead in 50 gallons of Bordeaux mixture, the latter being used to prevent leaf diseases.

Press Bulletins on Fall Destruction of Terrapin Bugs and Spring Destruction of Terrapin Bugs, and a regular Bulletin on Corn Weevils and Other Grain Insects have been prepared by the Entomologist during the year.

Respectfully submitted,

R. I. SMITH,
Entomologist.

REPORT OF VETERINARIAN.

I beg to submit a report of the work of the Veterinary Division for the year ending June 30:

The major part of the work has been given over to a study of the toxic effects of cotton-seed meal when fed to swine and guinea pigs. Both of these have been found to be quite susceptible to the ill effects of such feeding.

Daily observations have been made on nearly all of the animals fed, to determine, if possible, specific symptoms of the derangement produced by cotton-seed meal. With a number of the swine daily records were kept of weights, temperatures, pulsations and respirations. At frequent intervals blood readings were made, estimating amount of total solids, numbers of red and white corpuscles, the per cent of hemoglobin and specific gravity.

Post-mortem examinations have been made of all animals which died of cotton-seed meal feeding. In a number of instances weights were taken of various organs to compare with total weight, also portions of tissues were preserved for sectioning and for microscopical examination.

During the first half of the year work was carried on with the Bacteriological Division in an attempt to determine some of the poisons and their causes developing in milk. Samples of milk were inoculated with dirt and germs from various sources, and after a lapse of sufficient time for abundant germ growth the infected milk was injected into guinea pigs. Daily observations were taken, and upon the death of pigs post-mortem examinations and attempts to isolate germs from the blood were made.

During the year there were a large number of inquiries concerning hog cholera, and at one of the larger winter resorts, where the disease had just developed, we undertook to control its ravages by the production and use of hog-cholera serum, as advised by the National Bureau of Animal Industry. The owner had lost during the previous year nearly all of his swine except a few which recovered from the disease, and these afforded material necessary for preparation of the serum. The hogs were isolated as far as possible to delay or prevent infection until the serum could be produced, requiring some three weeks, according to the method pursued. Nearly one-fourth of the 200 head were sick or dead by this time, but after the injections of serum were made very few others became sick. As a curative agent after the symptoms of the disease developed it was found to be of little if any value, such as other investigators have observed, but its effect in preventing the trouble in those not infected was very marked. Some co-opera-

tive work with the State Department of Agriculture is being undertaken to further prove the efficiency of this serum in preventing and controlling hog cholera.

Internal parasites, being extremely common in pigs and shoats reaching the local market, turpentine and thymol are being compared as to their efficacy in freeing grossly infested shoats of worms.

A number of specimens have been received at the laboratory for examination, both bacteriologically and pathologically.

A marked increase in the number of inquiries concerning diseases in general has been noted.

Respectfully submitted,

G. A. ROBERTS,
Veterinarian.

RECEIPTS AND EXPENSES.

NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE
UNITED STATES APPROPRIATIONS, 1908-1909.

Dr.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1909, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	\$15,000.00	
Adams Fund	11,000.00	
	Cr.	<i>Hatch Fund. Adams Fund.</i>
By Salaries	\$7,313.88	\$8,272.76
Labor	2,203.45	1,181.09
Publications	662.56	.....
Postage and stationery.....	294.12	.....
Freight and express.....	84.29	.....
Heat, light, water and power.....	39.78	.....
Chemical supplies .....	.....	409.91
Seeds, plants and sundry supplies.....	565.33	223.34
Fertilizers	519.57	.....
Feeding stuffs	901.47	.....
Library	23.98	83.40
Tools, implements and machinery.....	373.65	.....
Furniture and fixtures.....	530.40	.....
Scientific apparatus .....	.....	171.75
Live stock	464.00	389.90
Traveling expenses	258.52	.....
Contingent expenses	15.00	.....
Buildings and land.....	750.00	267.85
Total	\$15,000.00	\$11,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1909; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been \$26,000, and the corresponding disbursements \$26,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed)

(Seal.)

J. T. ELLINGTON,
O. L. CLARK,
T. T. BALLENGER,

Auditors.

Attest: A. F. BOWEN, *Custodian.*

SCIENTIFIC PAPERS.

EFFECTS OF DIFFERENT FERTILIZING MATERIALS UPON THE MATURITY OF COTTON.

By C. B. WILLIAMS.

In fertilizer experiments which have been conducted at the North Carolina Station farm on a poor soil of the cecil sandy-loam type, deficient in organic matter, during the past five or six years, it has been observed frequently that the same variety of cotton planted on the same kind of soil and worked by identical methods matured differently on different plats, it being quite marked in some cases. From results secured at the Red Springs, Edgecombe, and Iredell Test Farms of the North Carolina State Department of Agriculture during two years, the writer made the same observations. These data and the deductions therefrom were published in September (1906) Bulletin of that Department. As results have been secured from coarse sandy, fine sandy loam, sandy-clay loam and tenacious clay soils for two to five years, it will be noted that the observations made and results secured have embraced many years' data and have covered a wide range of soils located under quite varying climatic conditions.

At the Station something like thirty tests have been conducted in which fertilizing materials were combined in different proportions and used in different quantities per acre, and in all cases a hastening of maturity was effected. On the unfertilized plats in all tests during all the years it has been found that in most cases the larger the yield the greater the combined percentage of seed cotton open at the first two pickings. At the end of the second picking there was but little difference, relatively, between the percentages of seed cotton open on those plats which received different quantities of fertilizer and different fertilizer combinations; but on these there was something like 50 per cent more open, as an average, than was on the plats which received no fertilizer application, but which had otherwise been subjected to the same treatment as the fertilizer plats. From the unfertilized plats about 75 per cent of the cotton was picked at third and fourth pickings; while those receiving an application of commercial fertilizer only had about 60 per cent of the crop left to open at these pickings, except in the case of the plat which received a mixture of 48 pounds of manure salt and 78 pounds of dried blood per acre, which had, on an average, 68.6 per cent. As showing the seasonal effect, especially of drouth, it will be found that by contrasting the results secured during the years 1904 (with an excess of .91 inch of rain during the months of August, September, October, and November) with those of 1905 (which had 3.45 inches deficiency from the normal for the months of August, September, October, and November, taken together, and 1.52 inches below normal for the month of November), it was found that the average percentage of total crop open on four unfertilized plats at the fourth picking was much greater in 1905 than in 1904.

EFFECTS OF CARRIERS OF PHOSPHORIC ACID.

As carriers of phosphoric acid, acid phosphate, basic slag and finely ground phosphate rock have been tested, and all have been found to hasten the maturity of cotton, as shown by the percentage of seed cotton open at first and second pickings. In fact, the hastening of the maturity was decidedly more marked from phosphatic fertilizing materials than from carriers of potash and nitrogen tried. Increasing the quantity of phosphoric acid derived from acid phosphate with normal amounts of potash and nitrogen was attended by a gradual increase in the percentage of total seed cotton open at the first picking.

Acid Phosphate.—When 196 pounds of acid phosphate was added to an application consisting of a mixture of 48 pounds of manure salt and 78 pounds of dried blood, there was almost 13 percentage increase in seed cotton open of total crop at the first picking and more than 7 percentage increase at the end of the second picking. This application also gave 22 at the first picking and 12 per cent at the end of second picking more of the total yield open than was secured from the adjoining plat which had received no fertilizer treatment.

Basic Slag.—Basic slag was found to hasten maturity even more than acid phosphate, as was shown by practically one-half of the cotton being open at the first picking on the plat which received an application of this material in connection with normal quantities (48 pounds of manure salt and 78 pounds of dried blood) of manure salt and dried blood. On the plat to which phosphoric acid, in connection with normal application of potash and nitrogen, was supplied from acid phosphate, it was found that about 12½ per cent less of total cotton opened at the first picking than did on the plat from which the phosphoric acid in equal quantities was furnished from basic slag under the same conditions. When this latter material was applied in the drill in connection with a ton of stable manure per acre, the effects upon hastening maturity were markedly reduced.

Phosphate Rock.—Where high-grade finely ground phosphate rock as a carrier of phosphoric acid was used at the rate of 274 pounds per acre (four times normal phosphoric acid) in connection with a ton of stable manure, and both were applied in the drill, it was noted that the percentage of total seed cotton open at the first picking was about 35 per cent and at the end of the second more than 20 per cent greater than on an unfertilized plat adjacent.

EFFECT OF CARRIERS OF NITROGEN.

Carriers of nitrogen used in fertilization, such as dried blood, nitrate of soda, etc., have been found to hasten the maturity of cotton, but not anyways near to the extent that carriers of phosphoric acid do. The effect of the common nitrogen carriers seems to be felt only at the first picking, as there is no evidence from results secured that they affected the percentage of total crop open at the second picking. When used with normal amounts of acid phosphate and manure salt, increasing the amount of blood, as the carrier of nitrogen, was attended by an increase in the percentage of total crop open at the first picking, up to 200 to 300 pounds per acre of the blood.

Dried Blood and Nitrate of Soda.—When 78 pounds of high-grade dried blood was added to normal quantities of acid phosphate (196 pounds) and

manure salt as a fertilizer application, the percentage of total crop open at the first picking was increased 3.3 per cent. Where in normal applications the amount of blood was reduced by one-half and an amount of nitrate of soda, equivalent in content of nitrogen to the reduction, was used as a side dressing and applied early in July, it was observed that the percentage of total crop open at the first picking was greater, generally, than in those cases where the whole of the normal application of nitrogen was derived from dried blood. When one-fifth of the nitrogen was derived from nitrate of soda and the remaining four-fifths came from dried blood, there was a rather marked increase in the percentage of total crop open at the first picking. When the nitrogen, in connection with normal quantities of potash and phosphoric acid, was derived from blood, one-half of which was applied at planting and the remainder reserved as a side dressing and applied early in July, it was observed that a larger percentage of total crop opened at the first picking than did where nitrate of soda was used as the carrier of nitrogen and which was divided and applied in the same way.

Cotton Seed and Stable Manure.—With cotton seed as a carrier of nitrogen and applied in the drill at planting, the effect upon maturity was about the same as where dried blood was used, while in the case of stable manure there was a material increase in the percentage of total crop open at the first picking, but showed no difference at the second picking.

EFFECT OF CARRIERS OF POTASH.

Manure salt was the only potash-bearing salt used. It was found, when used at the rate of 48 pounds per acre, to hasten the maturity of cotton but slightly. To be sure, the amount here used was quite small, and marked results were not expected where so small a quantity of any fertilizer material was used. Where one-half, twice, and thrice this quantity of manure salt was used in connection with normal amounts of phosphoric acid and potash, it was found that as the proportion of potash increased the percentage of total crop open at the first picking gradually diminished, except for the year 1907, August of which had about three inches less rainfall than normal.

EFFECTS OF LIME.

Slaked lime applied alone during the spring of 1903 and 1907 did not seem to increase the maturity of cotton in any year, as shown by the percentages open at the first and second pickings being about the same as for the unfertilized land; but, when used in connection with a normal application of a mixture of acid phosphate, manure salt, and dried blood, a marked hastening in maturity was noted. At the first picking, on an average, the addition of air-slaked lime at the rate of 1,000 pounds per acre every four years to a normal application of a complete fertilizer, resulted in an increase of more than 11 per cent of the total crop maturing than of the cotton planted on the plat receiving a normal application alone.

EFFECT OF DIFFERENT QUANTITIES.

It has been observed for the types of soil studied that increasing the amount of the application per acre of a fertilizer analyzing 7 per cent available phosphoric acid, $2\frac{1}{2}$ per cent nitrogen, and $2\frac{1}{2}$ per cent potash, from

200 to 800 or 1,200 pounds, that such an increase was accompanied generally by an increase in the percentage of total seed cotton of whole crop open at the first picking.

From the data used in preparing this paper, the following tentative deductions may be made relative to the influence of fertilizer upon the growth of cotton:

1. Fertilization with ordinary applications of commercial fertilizers hastens maturity.

2. Sandy and sandy-loam soils, whether fertilized or unfertilized, yield larger percentages of total cotton open at the first two pickings combined than do red-clay soils.

3. Heavy phosphoric acid ($N P_3 K$) fertilization on sandy and sandy-loam soils and medium heavy ($N P_2 K$) applications of phosphoric acid from basic slag have produced the largest percentages of total seed cotton open at the first picking.

4. Normal ($N P K$) fertilization yields on both sandy and red-clay soils a larger percentage open at the first picking than high nitrogen ($N_3 P K$) applications.

5. High nitrogen ($N_3 P K$) applications generally yielded on all types of soil studied larger percentages of total yield open at the first picking than high potash ($N P K_3$) applications.

6. Air-slaked lime alone does not hasten maturity, but when used in connection with commercial fertilizers it augments their influence in hastening maturity, as shown by percentage of cotton open at first picking.

SOME FACTS CONCERNING THOSE CHARACTERS OF THE CORN PLANT ASSOCIATED WITH YIELD AND FACTORS WHICH INFLUENCE THEM.

By C. B. WILLIAMS AND W. C. ETHERIDGE.

With corn, as with other crops, yield is determined by environment and by certain characteristics which the individual plants may possess. Without a favorable climate, good soil, and thorough tillage, no strain of corn can produce maximum yields any more than, with these supplied, can the greatest yields be secured where seed bred and selected in the most intelligent manner are not used. In consideration of these facts, it is deemed not inappropriate at this time to consider somewhat in detail some of those characters of the corn plant which seem to be associated intimately with high yielding capacity. The deductions made are largely from data secured with some sixty to seventy varieties of corn, many of them grown each under four different conditions—two of fertilization and two of distancing the hills in the rows.

I. CHARACTERS ASSOCIATED WITH YIELD.

Prolificacy in Ears.—As prolificacy is influenced by soil and climatic conditions, increasing the yield of any variety is usually attended by an increase in its prolificacy within narrow limits; and the larger the yield in grain of a variety, the larger the percentage of ear of total plant, the heavier the grain and the less pounds of ear-corn required to shell a bushel.

In variety tests on the Station farm during the past six years, as it has been found to be a pretty general rule that those which have averaged the largest yields of grain per acre were those possessing a decidedly strong tendency to produce more than one ear per stalk, it would seem to be safe to infer that the prolificacy of stalks in ears should be given prime consideration in selecting seed corn. In the Station tests it has been found that Sanders' Improved, a fairly prolific variety, has yielded as an average of five years 6.8 bushels more of shelled corn per acre than Holt's Strawberry, a good one-eared variety; while Biggs' Seven-ear, another prolific variety, has outyielded Holt's Strawberry 4.4 bushels as an average of three years' tests. Ordinarily, for the better grade of improved farming lands, it is not felt that it would be wise to select seed from stalks bearing more than two ears. It is believed that the richer the land on which the corn is to be planted the greater the prolificacy in ears that may be selected for with profit. On the poorer grades of land it is suggested that, until its yielding capacity has been increased, the best one-eared varieties be grown. Too great a prolificacy of corn to be planted on poor land may be a positive detriment to yield. The tendency of such seed will be to produce a large number of ears; and as the limited supply of available plant food contained in the soil will run quite low towards the latter part of the growth of the plants, there will usually be a large number of shoots and nubbins produced and very few ears; while, on the other hand, a one-eared variety might have given fairly good-size ears

under the conditions; certainly it would in all probability have done better. It might be stated in this connection that, where these conditions of soil obtain, it is thought that time might be put to better advantage in growing on it soil-improving crops, such as cowpeas and clover, and defer planting it to corn until it has been considerably improved in producing capacity. It is not felt that corn can be raised profitably on very poor land.

Percentage of Grain.—Although it is essential for any variety to possess the characteristic of producing a high percentage of grain to ear for it to attain its maximum yielding capacity, yet, as other factors, such as prolificacy, size of ears, source of seed, etc., enter, the largest yields need not necessarily be expected from those varieties possessing the highest percentage of grain. As a matter of fact, the largest yields by varieties tested at the Station farm during the past five years have been secured from those which produce a medium percentage of grain; but this is not because this is an unessential of the highest possible yields, but rather seems to be due to the fact that varieties possessing the highest percentages of grain have been bred and selected largely for this quality alone, while other characteristics that might have contributed to the yields were seemingly left out of consideration to a large extent in the establishment of these varieties. Increasing the size of the ear of any variety, it has been observed, is generally attended by an increase in the percentage of grain to ear, although to some extent this is modified by season.

The best yielding varieties have been found to bear ears which shell on an average of 80 to 87 per cent grain. With the same variety there is a seasonal variation of a fraction of a per cent to 2 to 4 per cent, or even more.

Size of Ears.—Large-eared varieties usually have a relatively low percentage of grain to cob, and are, as a rule, less productive of shelled corn per stalk than the more prolific varieties. Although, taking everything into consideration, where corn is gathered by hand, as is done in many portions of the South, it will usually be a little easier and slightly cheaper to gather and handle the same acreage of large-eared corn than of corn with smaller ears, when the yield of shelled corn per acre for both are the same, yet, quite frequently, from a financial standpoint, it will be better for the farmer to use seed of a variety possessing a relatively small ear, because of the greatly increased yield of grain per acre that would result from the use of such seed. Within reasonable limits, it should not be so much the size of the ears that should govern in the selection of a variety for seed purposes as the persistency of the seed of the variety to withstand adverse conditions and to produce large yields of shelled corn per stalk and hence per acre. However, within the same variety it will usually be advisable to choose for seed those ears, other characteristics being equal, that are of the average or slightly above the average in size for the variety.

The size of the ear of a variety is not determined solely by heredity, but is greatly influenced by climate, season, soil fertilization, cultivation, etc.; for the more favorable these conditions are for the growth of the plants, the larger and heavier will the ears and kernels produced be at maturity; and the more unfavorable these conditions are, the smaller they will grow. In other words, if seed of the same variety were planted during the same year on both rich bottom and ordinary upland soils, it would be found at maturity,

with a favorable season, that the corn grown in the bottom had not only produced a larger yield and greater number of ears per stalk, but had also borne considerably larger ears, and it would generally be easy for one who is at all familiar with ear types of different varieties to determine by general appearances whether a given ear had been produced on rich land or not.

It will be better to use seed of a variety having medium small ears with poorly shaped kernels in preference to one with large, well-shaped ears possessing well-formed kernels, if the former produces, under the same conditions of season, soil, and cultivation, greatly increased yields over the latter, notwithstanding the fact that it may be a little less expensive to house the latter, because the net profit resulting from the former would be much greater.

By using a variety with a strongly fixed prepotency to high yield of shelled corn per stalk—the great desideratum, after all—the size and shape of the ear and its kernels may be materially improved within a few years, through careful seed selection, with a resulting tendency to further increased yields over the original stock. It should be borne in mind clearly, however, that by developing larger and better-shaped ears and kernels of any variety, through seed selection, persistently practiced through a number of years, that only two of the many characters that contribute to high yields are improved.

Height of Ears and Stalks.—It has been found that the best yielding varieties were those which possessed a medium to tall stalk and were those which have their ears at a medium height. The varieties which had the lowest stalks and ears were those seed of which have come from the corn-growing States of the Northwest. The ears should be attached a little below the center of the stalks. Varieties which make too large a growth of stalks are generally late in maturing and are therefore far more likely to be caught by early frost in the fall than those that make a relatively small or medium growth of stalk.

Date of Maturity.—As a general thing, those varieties which mature earliest are the smallest yielders of both grain and stover, while those producing most per acre are medium to late maturing. Other things being equal, earliness in maturity of not only corn, but all other crops, is at a sacrifice of yield, as earliness and high yield are antagonistic characters, if a favorable growing season is afforded for the maturity of the later maturing varieties. Usually, also, earliness is accompanied by a high percentage of ear to stover; but this ratio is more or less influenced by season, soil, fertilization, breeding and selection. It might be stated here that with many crops, however, earliness is more essential than heavy yields; especially is this so with trucking crops, for if they do not reach maturity early in the season the best prices are not obtained. Where for any reason the season for growth is short, the best of the early varieties will give the largest yields under the conditions, but the yield will be smaller generally than would have been produced by the best of the medium and late maturing varieties had the season been sufficiently long for their full development.

II. DIFFERENT DISTANCING OF HILLS IN EQUIDISTANT ROWS UNDER DIFFERENT DEGREES OF FERTILIZATION.

Effect Upon Yield.—The optimum distancing for yield of corn, as with other crops, is governed by variety, season, soil, fertilization, cultivation,

etc. For the same soil, the more favorable the season, fertilization, and cultivation, the closer, within limits, the planting may be done with profit, especially so with the prolific varieties. To illustrate specifically the effects of fertilization under local conditions which embody principles of wide application, it was found that as an average of the yields of 68 varieties, planting at 20 inches in the row produced 3.8 bushels more shelled corn and 563 pounds of stover per acre on highly manured land than did spacing the hills 30 inches in the row; while on the same land which did not receive but 300 pounds of commercial fertilizer per acre the yield of grain and stover was practically identical at both distancing (20 and 30 inches) and were but little more than one-half those obtained from the highly manured plats of the same acreage. With the highly manured plats, 76.1 per cent of the varieties yield most shelled corn per acre at 20-inch spacing of the hills as against 30 inches, and those which did not follow this rule were all of one-eared type. In the case of stover, 86.6 per cent of the varieties yielded most where the stalks stood 20 inches in the row on the highly manured plats. On the better manured plats, 85.1 per cent of the varieties yielded a greater value of total products (grain and stover) at 20-inch spacing in the rows. With varieties receiving an application of (cow) manure supplemented by 300 pounds of commercial fertilizer, the value of total products was \$5.29 more per acre where the stalks were 20 inches than where they were 30 inches; while on the same land which received only 300 pounds of commercial fertilizer per acre the difference was, on an average, not but 23 cents, which was in favor of 20-inch distancing in the rows. From the above, therefore, it is observed that increasing the productivity of the soil by a fairly liberal broadcast coating of (cow) manure and fertilizer was accompanied by materially increased yields, over 30-inch spacing, by thinning the stalks to 20 inches, while under ordinarily poor fertilization there was practically no difference between a spacing of 20 and 30 inches of the hills in the rows, which emphasizes the importance of closer planting as the fertility of the land is increased.

Results in these experiments were secured from 68 varieties of corn grown in 4-foot rows during 1908 on poor land of the Cecil sandy-loam type which would not normally without fertilization yield more than 12 to 14 bushels per acre. The land was treated in two sets in different degrees of fertilization. On one set of plats, which will be termed the "highly manured" set, 16 tons of a high-grade cow manure (the cows had been fed on cotton-seed meal and wheat bran, and no bedding was in the manure), supplemented by an application of 300 pounds per acre at planting of a fertilizer analyzing 7 per cent available phosphoric acid, 3 per cent nitrogen, and $1\frac{1}{2}$ per cent potash was used; while the other set received only 300 pounds of commercial fertilizer per acre of the grade given above. This set in the discussion that follows will be called the "poorly fertilized" one.

Effect Upon Size of Ears.—Under heavy manuring, stalks which were 30 inches in the row produced ears, on an average, which were .37 inch longer and .12 inch greater in circumference than those grown on stalks standing 20 inches apart; while on the poorly fertilized plats the ears were .44 inch longer and .16 inch greater in circumference at 30-inch than those grown at 20-inch spacing of the stalks. The average length and circumference of the

ears on the more highly manured land were .99 and .46 inch respectively greater than where the 68 varieties were grown on the poorly fertilized plats. On the highly manured land 84.6 and 68.2 per cent and on the poorly fertilized plats 79.1 and 76.1 per cent of the varieties produced ears longer and circumference of same greater respectively at a spacing of 30 inches. As an average of all the varieties, it required 122 ears to shell a bushel from hills thinned to 30 inches and 131 ears at 20 inches on the highly manured plats; while for the poorly fertilized corn, it required 166 ears at 30-inch-grown and 200 ears of that grown 20 inches in the row. On the poorly fertilized plats it required an average of 56 ears more to shell a bushell of corn than it did where the corn was produced on the better land. On the highly manured plats 72.7 per cent of the varieties required a larger number of ears to shell a bushel where the corn was grown 20 inches apart in the rows; while on the poorly fertilized plats 83.3 per cent of the varieties required most at the same distancing. On the highly manured plats it will be observed that a 20-inch distancing of the hills gave the largest yields, while stalks spaced 30 inches produced the largest and longest ears. Both higher fertilization and greater distancing between hills increased the length and circumference of the ears of two-thirds to three-quarters of all the varieties under experiment.

Effect Upon Height of Stalks and Ears.—On the highly manured plats the height of the stalks and ears were 2.30 and 1.60 inches higher respectively at a spacing of 20 inches between the stalks than at 30 inches; while on the poorly fertilized plats the stalks and their ears were 5.50 and 1.70 inches higher above the ground respectively at 30 inches. The average height of the stalks and ears under better manuring were 11.35 and 6.40 inches higher respectively than those grown on the poorly fertilized plats. Of the stalks and their ears of the 68 varieties, 67.2 and 68.7 per cent at 30 inches, and 83.8 and 69.1 per cent at 20 inches, were highest on the heavily manured and poorly fertilized plats respectively. It would seem, then, from these data that in the presence of limited quantities of plant-food in the soil an increase in the distance between stalks from 20 to 30 inches of corn planted in 4-foot rows leads to the production of a taller growth of stalks and higher attachment of ears above ground; while with the same soil fairly well supplied with plant-food from (cow) manure and fertilizer for the immediate needs of the plants an increase in the thickness of planting from 30 to 20 inches is attended by the growth of higher stalks and ears.

Effect Upon the Number of Ears and Amount of Shelled Corn per Stalk.—On the highly manured plats there were for all the varieties taken together .11 more ear per stalk at 30 inches than at 20 inches spacing of the hills in the row, and on the plats receiving only 300 pounds of commercial fertilizer .10 more of an ear on an average at 30 than at 20 inches. Contributing to these data 91.0 per cent of the varieties on the highly manured land and 86.8 per cent on the poorly fertilized plats produced most at the respective favorable distancings. The average difference between the highly and poorly fertilized plats was .15 more of an ear per stalk on the former than on the latter. The corn under better fertilization produced 27 per cent more shelled corn per bearing stalk at 30-inch distancing than at 20 inches; while that grown on land poorly fertilized, an increase of 41 per cent was secured in

favor of the former distancing, which indicates that in the presence of limited quantities of plant-food a slight increase in the amount of space per plant is attended by a much greater increase in yield of grain per stalk than is secured on land which is more highly manured. The highly manured plats, as an average of both distancing, produced .148 pound shelled corn per bearing stalk, or an increase of 68.4 per cent more shelled corn per bearing stalk than was produced on the plats receiving 300 pounds of commercial fertilizer alone. It will be observed that increasing the distance between the hills and the fertility of the land were attended by a larger number of ears per stalk and by a marked increase in the quantity of shelled corn per bearing stalk.

Effect Upon Maturity and Stand.—The two distancing of hills studied did not seem to affect differently to any great extent the growth of the plants up to the tasseling and silking stages, yet the weight of evidence is that closer spacing of the stalks retarded the maturity by about one day, on an average. The corn on the highly manured plats tasseled and silked from three to four days earlier than on those receiving an application of commercial fertilizer alone. Better fertilization seems to lead to a more perfect stand, as is evidenced by the varieties planted on the plats which received an application of (cow) manure and 300 pounds of commercial fertilizer being 2.56 per cent better than that from seed of the same varieties planted in the same manner on the same type of soil which received only an application of commercial fertilizer.

Effect Upon the Production of Suckers.—On the more highly fertilized plats 9.48 per cent at 30 inches and 6.13 per cent of the stalks produced suckers at 20-inch spacing of hills in the row; while on the poorly fertilized plats 6.15 per cent produced suckers at 30 inches and 2.87 per cent at 20 inches. Suckers, therefore, are increased in number both by increasing the distance of the hills apart and by the addition of more plant-food to the soil. It has also been observed repeatedly that under the same conditions some varieties produce many times more suckers than do others, hence the production of these is a varietal characteristic which is influenced by fertilization, spacing of plants and other environmental factors.

Effect Upon Barrenness.—By decreasing the distance between hills from 30 to 20 inches on the manured plats the percentage of barren stalks was increased from 1.73 to 3.42 per cent, while on the poorly fertilized corn it was raised from 5.26 to 10.73 per cent. It will be noticed from these data that for both the sets the percentage of stalks barren was doubled by a decrease in the distancing of the hills in the row by 10 inches, and that the corn on the poorly fertilized plats was affected with more than three times the percentage of barrenness that prevailed on the plats receiving (cow) manure and commercial fertilizer. Therefore, barrenness seems to be decreased both by an increase in the distance between hills in the row and by heavier and more favorable fertilization.

VARIATION OF FUNGI DUE TO ENVIRONMENT.¹

BY F. L. STEVENS AND J. G. HALL.

The effects of environment, climatic condition, soil fertility, the presence of unusual chemicals, the water relation and what not upon the form and characters of seed plants are well known to the plant physiologist, and have been the subjects of numerous studies. These factors are even utilized by the practical man to bring about desired variation.

That fungi vary similarly will not be doubted by any who have had to do with fungi in artificial cultures. The kind and degree of such variation, we dare say, will be a surprise to any who have made special study of this subject.

While our knowledge of the seed plants, owing to man's long acquaintance with them, their larger size and comparative stability is considerable, yet even with them the limiting of genera, species, varieties, etc., presents difficulty, if we may judge from the rich literature upon phanerogamic taxonomy. The fungi, because of their immense number of species, variety of forms, minuteness, paucity of distinguishing characters, complexity of life-history (mostly unknown) peculiar biologic host relations (almost entirely unknown), and because of man's short acquaintance with them and their unknown but apparently vast range of variability, present as yet baffling problems of relationship and classification.

The object of the present article is to call attention to the kind and degree of environmental variation found in a few species of fungi that have been studied by the authors during the past four or five years and in some instances to analyze the causes of these variations to the end that the factor of environmental variation may be more clearly recognized as a problem of mycological taxonomy.

We shall consider these variations under the causes that produce them.

I. DENSITY OF COLONIES.

Septoria petroselini Desm. var. *apii* Br. and Cav., from celery.

This fungus, when plated so that the spores lay thinly scattered, produced colonies which were ultimately black, from 1 to 2 mm. in diameter, with pycnidia of normal character; if plated so that the spores lay in large numbers per square centimeter, it produced colonies which reached a size of only about .5 mm. and became ultimately black, containing ordinary pycnidia, bearing spores in the normal way. When plated so that there were still more spores per square centimeter, the colonies never became black and no pycnidia were produced; but to the contrary, multitudes of spores were borne uncovered, in clumps upon simple hyphæ.

Septoria lycopersici Speg., from tomato.

Spores from pure culture were plated in 4 per cent pea agar in various dilutions.

¹Read in part at the Baltimore meeting of the Botanical Society of America, December, 1908, and published in the *Botanical Gazette* 48 (1909).

One plate developed 5 to 6 colonies per square millimeter and each colony proceeded to normal pycnidial development. Another plate developed 21 to 23 colonies per square millimeter and all proceeded to form naked conidia with no indication of pycnidia. Portions of these two plates are represented

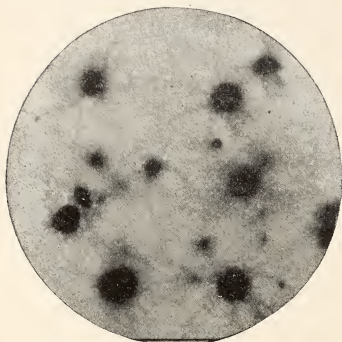


FIG. 1.—*Septoria Lycopersici* Speg., showing formation of normal pycnidia on portion of thinly sown plate culture.

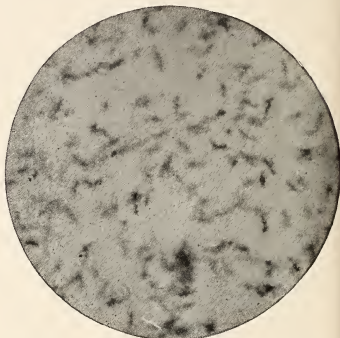


FIG. 2.—*Septoria Lycopersici* Speg., showing absence of pycnidia on thickly sown portion of plate culture; magnification same as in Fig. 1.

by photomicrographs (Figs. 1 and 2). Drawings of the naked spores showing the detail of their formation are given in Fig. 3. Occasionally plates with as many as 30 colonies per square millimeter were found with both pycnidia and naked spores.

Pycnidia not visible at the fifth day may be well formed by the sixth day and extrude masses of pink spores about the twenty-first day. Occasionally pycnidia are well developed on the fourth day. When naked spores develop they normally appear a few days later than do pycnidia, *e. g.*, a plate thinly sown on January 12, 1907, gave many pycnidia on January 15, while a thickly sown plate, under conditions otherwise precisely parallel, did not give naked spores until January 22.

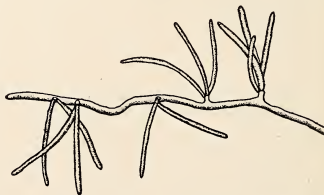


FIG. 3.—Mode of formation of naked spores under influence of crowded culture.

This septoria forms a typical determinate colony, *i. e.*, even with unlimited room, it proceeds only to a certain size of development.

Septoria consimilis E. & M., from lettuce.

When sown thinly colonies reached a size of 2 to 3 mm. in diameter; when sown thickly they became no more than .2 mm. in diameter. There was no interference with color development or formation of pycnidia by thick sowing with this species.

With two of these septorias, thick plating, other conditions being the same, so changed their character that not only would the species be considered as different, but the fungus would be shifted from the *Sphaeropsidales* to the *Hyphomycetales* (Hyphaea of Saccardo).

A similar change of habit is well known in the genus *Fusarium*, which in culture, crowded or not, often abandons acervulus formation, thus changing its systematic position from the *Tuberculariaceae* to the *Mucedinaceae*. The genera *Colletotrichum* and *Gloeosporium* similarly abandon acervulus formation and thus suffer still greater taxonomic disturbance by moving from the *Melanconiales* to the *Hyphomycetales*.

Ascochyta chrysanthemi Stevens, from chrysanthemum.

This fungus was plated January 12, 1907. Myriads of pycnidia were present four days later; thick plating caused no inhibition of pycnidial formation, no naked spores and no constant effect upon the number of pycnidia produced.

Volutella fructi S. & H., from apple.

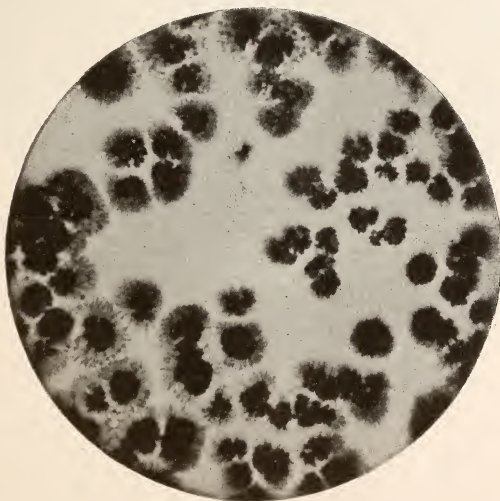


FIG. 4.—*Volutella fructi* S. and H., showing colonies on thinly sown plate culture.

Thinly sown, the colonies were large, of indeterminate growth, showing dark centers with pale borders (Fig. 4); thickly sown, growth was inhibited and their characters lost. (Fig. 5.)

Spermocdia paspali Fries, from *paspalum*.

Spores of this fungus were sown January 19, 1907, in plates giving colony densities of 90, 54, 30, 14 and 1 per square mm.

At all of these densities germination was practically 100 per cent and growth proceeded equally in all plates during the early stages. On February

11 it was noted that all colonies which came nearly in contact were sporing. Growth then stopped. In the plates bearing only one spore per square millimeter the colonies continued to enlarge slowly and to produce many spores in the central portion, though remaining white, not attaining the usual yellow color. Deep colonies appeared like the superficial, but bore no spores. On

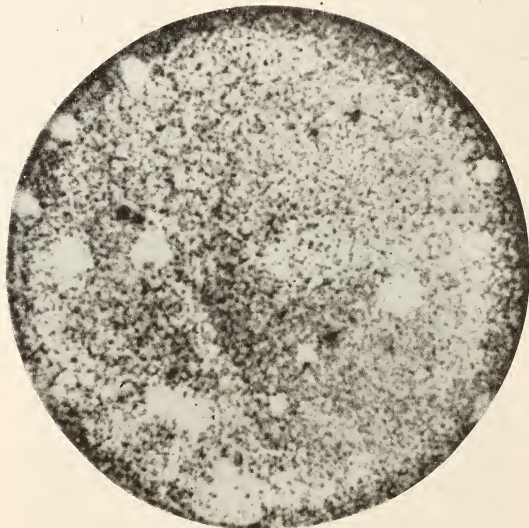


FIG. 5.—*Volutella fructi* S. and H., showing effect of thick sowing.

February 7 the colonies on thin plates (1 per square millimeter) had attained a diameter of 1.5 mm. Some of those colonies transferred to tubes continued to enlarge, became tubercular, and developed a yellow center 3 or 4 mm. in diameter. The whole colony often reached 1 cm. in diameter. Sister colonies left in the plate (1 per square millimeter) failed to so develop, and it is evident that at even this density normal development is not attained.

The colony is indeterminate in growth and in plates its size is limited by the presence of adjacent colonies.

SUMMARY REGARDING THE DENSITY FACTOR.

This factor produces different effects with the different species. It may inhibit pycnidial formation, resulting in naked spores; it may cause failure to develop color; it may limit the size of the colony; or it may be without effect.

There are many paired species of the imperfect fungi agreeing closely, except in the presence or absence of one character. These pairs often occur

upon the same host, *e. g.*, *Septoria lycopersici* Speg. and a *Cylindrosporium* on the tomato, and *Cylindrosporium Chrysanthemi* E. & D. and *Septoria Chrysanthemi* Cav. on the cultivated chrysanthemum.¹

Many other instances could be cited.

The lack of fixity of such a structure as even the pycnidium throws doubt upon the validity of such species as these and indicates the necessity of close comparative study.

II. DENSITY OF MYCELIUM: ZONE FORMATION.

The formation of concentric zones is by many fungi one of the most conspicuous characters shown in cultures. These zones may be due to any one of many structural characters of the colony; to varying density of spore mass-

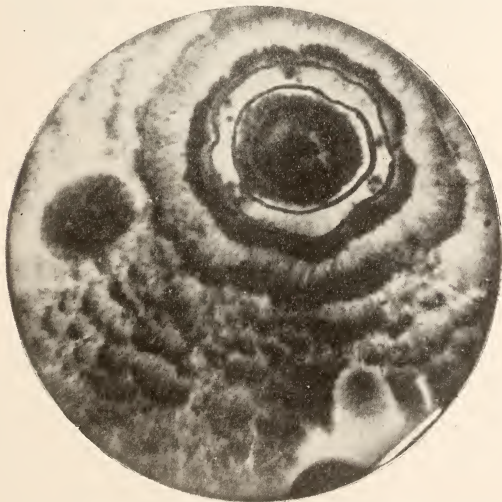


FIG. 6.—*Ascochyta Chrysanthemi* Stevens; plate culture showing that the formation of zones is not coincident with diurnal changes; ink marks show growth for three consecutive days.

ing; pycnidia grouping, mycelial branching, color, etc. It is a frequent phenomenon in nature in the fairy rings of the toad stools, the concentric markings of many leaf spots, fruit rots, etc. These effects have been attributed to

¹VOGLINO, Diseases of cultivated chrysanthemums, *Malpighia* 15 (1902), 329-341. E. S. R. 14, 777.

²HALSTED, Chrysanthemum leaf spot, *American Florist*, 10 (1894), No. 333, 263. E. S. R. 6, 311.

³BEACH, Leaf spot of chrysanthemum, *N. Y. State Sta. Rpt.*, 1892, 557-560.

⁴HALSTED, Report of fungus disease of plants, *N. J. Sta. Rpt.*, 1891, 233-340.

⁵Sacc. *Syll. Fung.* 11, 542, Nos. 3497, 3498, 3757. Tübeuf and Smith, *Diseases of Plants*, 478. Year-Book U. S. Dept. Agr., 1906, 507. *Geneva Sta. Rpt.*, 14, 529. *N. J. Sta. Rpt.*, 1894, 361.

various causal agencies: to light relation,¹ to nutrients,² to agencies other than light, probably food, and to resting periods and to mycelial crowding.³

Ascochyta chrysanthemi Stevens.

With the fungus in question the fact that the zones are not due to light or temperature relations is apparent from the fact that they do not coincide with the fluctuations of these two factors (Fig. 6). In the colony shown, which is that of a plate culture kept at room temperature, there was daily change from warm to cool, light to dark, yet the number of rings does not coincide with the number of these changes; moreover, zones were produced in precisely the same way on plates kept constantly in the dark as in plates kept all of the time in the light, and still the same on plates kept three days in the dark and then three days in the light.

Microscopic examination shows that with this fungus the dark zone is due to a larger number of mycelial filaments, the light zone to a smaller number of threads, as is shown diagrammatically in Fig. 7. It seems that with this

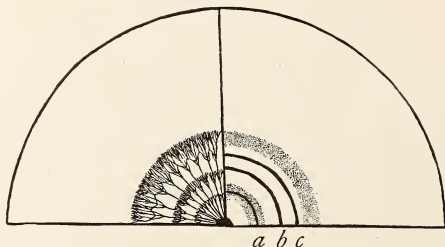


FIG. 7.—Diagram showing, at right, the zones (stippled) and diurnal marks; at left, theoretical expression of cause of zonation.

fungus the dense crowding of the filaments resulting from their repeated branching inhibits growth either by the products of metabolism or exhaustion of nutriment. There is then a period of quiescence, followed by onward growth of a few scattered hyphæ. As these outgrowing hyphæ reach beyond the inhibiting influence, they branch repeatedly until a new dense zone is formed. This process is repeated indefinitely. The rapidity of succession of zones is dependent solely upon the relation which rapidity of branching bears to rapidity of increase in length. Slow lineal growth and much branching gives many narrow zones; rapid lineal growth with infrequent branching causes broad zones.

Sclerotinia Libertiana Fckl., from lettuce.

Zonal sclerotial formation is exhibited by this fungus. (Fig. 8.) That this phenomenon may be attributed to crowding of the mycelium is indicated by the fact that adjacent colonies form more sclerotia at their points of contact. (Fig. 9.)

¹MOLZ, "Ueber die Bedingungen der Entstehung der durch *Sclerotinia fructigena* erzeugten." Schwarzfäule der Aepfel. Cent. f. Bak. II, Ab. 17, 175.

HUTCHINSON, "Ueber Form und Bau der Kolonien niederer Pilze." Cent. f. Bak. II, Ab. 17, 602. Also

HEDGECOCK, Zonation in Artificial culture of *Cephalothecium* and other fungi. Ann. Rpt. 17, Mo. Bot. Gard., 1906.

²MILBURN, Ueber Aenderungen der Farben bei Pilzen und Bakterien. Cent. f. Bak. Ab. II, 13, 257.

³ISTVANFI, Etudes Microbiologiques et mycologiques sur le rot gris de la vigne. Am. de l'Institut Cent. Ampel. Roy. Hongrois, 1905, 183.



FIG. 8.—*Sclerotinia Libertiana* Fckl., showing zonal formation of sclerotia on corn meal culture.

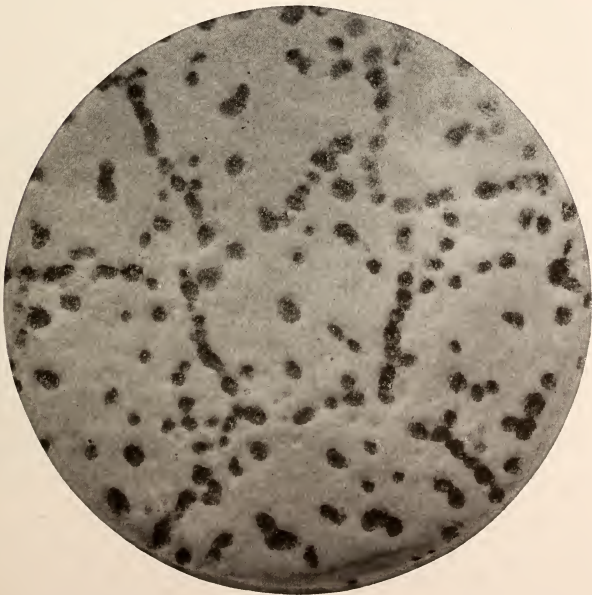


FIG. 9.—*Sclerotinia Libertiana* Fckl., showing the formation of sclerotia in greater abundance where adjacent colonies come in contact.

SUMMARY REGARDING DENSITY OF MYCELIUM.

Zone formation in *Ascochyta Chrysanthemi* is due to crowding of mycelium, not to light or heat relation. A similar conclusion was reached by Istvanffi (Istvanffi lc.) regarding the very striking zones shown by *Sclerotinia*. The same causes may apply also with *Daldinia concentrica* and many other fungi of similar structure.

III. CHEMICAL RELATIONS.

Chemical relations have been studied with eleven fungi, the fungus being usually grown in agar with varying nutrients added. Occasionally other media were used. A chemical base agar (cba) was made of the following proportion:

Water	1,000	grams.
Di-potassium phosphate	2.5	grams.
Calcium chloride .....	.01	gram.
Magnesium sulphate .....	.01	gram.
Sodium chloride	2.5	grams.
Potassium sulphate	2.	grams.
Agar	15.	grams.

To 100 cc. of this chemical base agar were added the following materials singly or in varying combinations:

Ammonium lactate .....	.5	gram.
Sodium asparaginate .....	.25	gram.
Glucose	1.	gram.
Starch	1.	gram.

The tests were usually made in both plate and tube cultures.

Volutella fructi S. and H., from apple.

This fungus, when sown thin, forms large indeterminate colonies, often with numerous scattered tubercular blotches (Fig. 10).

On pure agar and cba the colonies were pale; mycelium hyaline; black tubercles very sparse.

On pea agar black tubercles were much more abundant, otherwise as on pure agar.

On cba+sodium asparaginate black tubercles were still more numerous.

On cba+sodium asparaginate+starch black tubercles were more numerous than in any of the above, and the colony was black (Fig. 11).

On cba+sodium asparaginate+glucose black tubercles were still more numerous, so many as to be contiguous, and the whole colony was densely black.

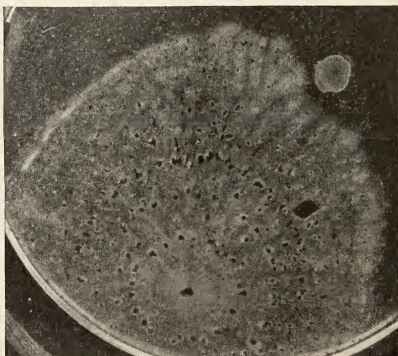


FIG. 10.—*Volutella fructi* S. and H.; colony on pea agar showing tubercular blotches, some of them in concentric rings; mycelium nearly hyaline, due to lack of carbohydrates.

On gelatinized starch+Uchinsky's solution the mycelium was black, and some digestion of the starch was observed.

On none of the above media were spores formed, but on sterilized apple twigs spores were produced in abundance.

The differences here noted upon these different media are sufficient to alter entirely the general appearance and to shift the fungus from the Tuberculariaceae-Dematiae to the Tuberculariaceae-Mucedinae.

Coniothyrium Fuckelii Sacc., from apple.

This fungus when growing upon a medium rich in starch becomes black in its peripheral layer. Glucose fails to produce the same result. The mycelium hyaline when on pea agar, but tawny on apple agar.

Septoria petroselinii var. *apii*, from celery.

This fungus fails to produce naked spores when sown thickly on celery agar, though it does so under similar conditions when upon lettuce agar.

Colletotrichum carica S. and H., from fig.

This fungus upon the different media used showed striking differences in number or setae, varying from none to abundant; number of spores varying from few to many; color, varying from pale to almost black.

On cba+growth was scant; acervuli small, setae absent.

On cba+ammonium lactate and cba+sodium asparaginate growth was about as in cba, except that numerous black setae were present.

On cba+ammonium lactate+starch the acervuli were larger, more numerous, with numerous large black setae.

On cba+sodium asparaginate+glucose, black setae were numerous.

On cba+sodium asparaginate+ammonium lactate there were a few setae.

Epicoccus sp. *indet.*, from apple agar in Petri dishes.

This fungus on pure agar and cba was colorless. On cba+starch or cba+glucose there was much richer mycelial development which, moreover, took on a rich yellow color that in spots turned to pink. Sometimes black spots developed on the first of these media, but not upon the second. This fungus shows strikingly the differentiating value of starch and glucose for fungus culture.

Upon apple agar still another character developed, a rich golden color of the abundant floccose matted aerial hyphae. This reaction is fully as striking as the familiar rose color produced by a certain species of *Fusarium*.¹

With this fungus we have absence of color in agar and cba, but rich coloring of varying hues in the presence of carbohydrates and upon apple agar.



FIG. 11.—*Volutella fructi* S. and H.; two black colonies upon cba + sodium asparaginate + starch.

¹BESSEY, Ueber die Bedingungen der Farbbildung bei *Fusarium*, Inaug. Diss. Halle., 1904.

Phyllosticta sp. indet., from apple agar in Petri dishes.

This fungus grew faster on agar than on cba, formed pycnidia sparsely on agar and not at all on cba.

With sodium asparaginate added the mycelium becomes very dense, with considerable aerial development, remains colorless and produces few pycnidia, and these visible only with the two-third objective. The presence of glucose led to exceedingly profuse pycnidial development, while on starch the growth was as with cba+sodium asparaginate, showing again the ability to utilize glucose, but not starch.

Alternaria sp. indet., from Lawson carnation.

This fungus, the cause of an apparently undescribed carnation disease which will be the subject of a subsequent paper, was isolated during October, 1908. There was striking difference in the color of the colony upon different media, varying from merely hyaline to dense black. The size and color of the spores was also so modified as to give much more than what is usually regarded as a specific difference.

On pure agar, cba, cba+ammonium lactate, cba+sodium asparaginate, and upon cba+ammonium lactate+sodium asparaginate, the mycelium was colorless and the colony correspondingly colorless, while upon cba+sodium asparaginate+starch and cba+sodium asparaginate+glucose the mycelium was very dark, more profuse, more freely branched, and the colony therefore of an entirely different aspect.

Spore formation proceeded sparingly, though evenly and regularly, upon pure agar, cba, cba+ammonium lactate, cba+sodium asparaginate, cba+sodium asparaginate+ammonium lactate; but very abundantly upon cba+sodium asparaginate+starch and upon cba+sodium asparaginate+glucose. Here the sodium asparaginate seems not to furnish the carbon in sufficiently available form, though starch or glucose do so to nearly equal extent.

The size, color and septation of the spores were also greatly influenced by the medium.

From carnation-agar plates the spores measured from 16 to 52 mu long by 6 to 13 mu thick, bearing from none to three longitudinal septa and from 3 to 7 transverse septa, while from the live carnation leaf the spores were from 26 to 123 mu long by 10 to 20 mu thick, bearing from 1 to 9 or often numerous longitudinal septa and from 3 to 15 transverse septa. It is seen that the spores are approximately twice as long, twice as thick, of darker color and with many more septa in each direction upon the natural medium than upon the carnation agar, differences which would ordinarily be regarded as clearly of specific rank.

Alternaria Brassicae (Berk.) Sacc., from collard.

This fungus made hyaline mycelium in cba and cba+sodium asparaginate; black mycelium in cba+sodium asparaginate+glucose and in cba+sodium asparaginate+starch, starch producing by far the most pronounced effect.

Digestion of the starch grains, somewhat in advance of the tips of the oncoming fungus threads, produced a clear zone surrounding each colony in the starch-bearing plates.

Ascochyta Chrysanthemi Stevens.

This fungus was grown in the usual media with no significant effects, except that the fungus did not digest the starch grains afforded in the medium.

A deposit of great thickness around mycelial threads was made in the case of certain media and not in others, as has already been noted.¹

In some instances culture at a high temperature occasioned this same response.

SUMMARY OF CHEMICAL RELATIONS.

The most striking response to chemicals is in color, which so far as observed was invariably heightened by the presence of chemicals bearing carbon in available form, the form of available carbon varying for different fungi. Some fungi, possessing ability to digest starch, can utilize this as a source, while to others the carbon of starch is inaccessible. Special unknown chemicals in apple add vivid colors to fungi otherwise hyaline. Some chemicals also promote or inhibit spore formation. Some inhibit or promote growth of setae, and some even alter the size, color and septation of spores. Milburn, working under Klebs (Milburn, lc.), has also noted pronounced effects of chemicals upon the color of fungi. The difference in color effects produced by different fungi under the same conditions and with the same fungus under different conditions is also noted by Bessey.²

No correlation is noted between rapidity of lineal growth and nutritive value of the medium. In many instances most rapid lineal growth occurred in what was surely the poorest medium. Very poor media suffice in many cases also for spore formation, while rich media often result in cessation of spore formation.

Colletotrichum Lindemuthianum, sometimes with setae, often without, has long been of questionable generic position. The same is true of several other species of this genus. *Alternaria Brassicae* and *Macrosporium Brassicae* agree closely except as to presence or absence of catenulate spores.³

Variation of this kind is probably due to variation in chemical composition of the supporting medium, *e. g.*, change in sugar content as ripening proceeds, acting in such way as to give the fungus the appearance of belonging to one genus when upon the green sugar-free fruit, to another genus as the starch gives place to sugar as the fruit ripens.

IV. LIGHT RELATION.

The absence of material effect of light upon lineal growth with these species of fungi is shown in Table I.

¹Bot. Gaz., 44, 1907, 241.

²Bessey, lc.

³*A. Brassicae* Hyphae brevis conidia 60-80 x 14-18, septae 6-8.

M. Brassicae Hyphae obsoletis conidia 50-60 x 12-14, septae 5-11.

TABLE I.—*Relation of Light to Growth.*

Figures express growth in millimeters. The cultures marked "alternate" were kept several days in light and several days in dark; L=light, D=dark. Inoculated December 8, 1908.

DATE OF OBSERVATION.	CONDITION OF LIGHT.								
	On Macrosporium Brassicæ.			On Phyllosticta sp. indet.			On Ascochyta Chrysanthemi.		
	In Light.	In Alter- nate Light and Dark.	In Dark- ness.	In Light.	In Alter- nate Light and Dark.	In Dark- ness.	In Light.	In Alter- nate Light and Dark.	In Dark- ness.
December 9--	Germ	Germ L	Germ	0	0 L	0	0	2 L	0
December 10--	1	1 L	1	Germ	Germ L	Germ	Germ	3 L	6
December 12--	6	6 L	6	4	4 L	4	4	12 L	12
December 13--	9	10 L	9	7	7 L	6	12	16 L	14
December 14--	13	12 D	11	10	10 D	7	15	20 D	18
December 15--	16	15 D	15	13	13 D	10	17	25 D	22
December 16--	17	17 D	17	14	13 D	13	25	30 D	25
December 17--	23	23 L	21	16	16 L	16	33	37 L	31
December 18--	26	26 L	29	20	18 L	19	39	39 L	37
December 19--	28	28 L	29	23	20 L	20	41	45 L	37

Ascochyta Chrysanthemi Stevens. The growth is more floccose in darkness.

Phyllosticta sp. indet. This fungus forms its pycnidia in beautiful concentric rings when in open room, *i. e.*, alternate light and darkness, but in continuous darkness they were irregularly scattered. Culture No. 35 made concentric rings when in the light and failed to do so when moved to darkness. Cultures kept in the open room lay down rudiments of pycnidia mainly during the night, and it is probable that light exerts enough inhibiting influence on pycnidial development to give a growth predominance during the day and a fruitifying predominance during the night.¹

Alternaria Brassicæ (Berk.) Sacc. With this fungus the end of each day's growth, evening, marks the edge of a zone. The zone thus marked is intensified during the succeeding twenty-four hours by color changes. While zones are formed to some extent in continued darkness, they are more pronounced in the room condition.

SUMMARY OF LIGHT RELATION.

Light exerts little or no effect upon lineal growth with these fungi. It appears to exert an inhibiting influence on pycnidial development and in some instances is the cause of zonation in colonies.

V. UNKNOWN FACTORS.

Ascochyta Chrysanthemi Stevens.

This fungus frequently exhibited differences in character along different radii of the same colony, the conditions of medium, thickness of sowing, humidity, etc., being apparently identical. Fig. 12 shows such a colony. Along the radius *a*—*a* at *b* the colony bore pycnidia abundantly, and the mycelial

¹Hedgecock, 1c.

progeny of this strain extending to the periphery of the colony was rich in pycnidia, while most other radii of the colony were sterile or nearly so. Transfers were made from the point *c* (sterile) and *d* (pycnidial) to fresh plates. The sterile mycelium produced a colony which through its early days was sterile. As it aged it formed a few large pale pycnidia. The fertile strain produced a fertile colony with very numerous though small pycnidia. Transfers made again from these two strains resulted in a complete reversal of character, the fertile becoming sterile and the sterile becoming fertile. No explanation of this suggests itself.

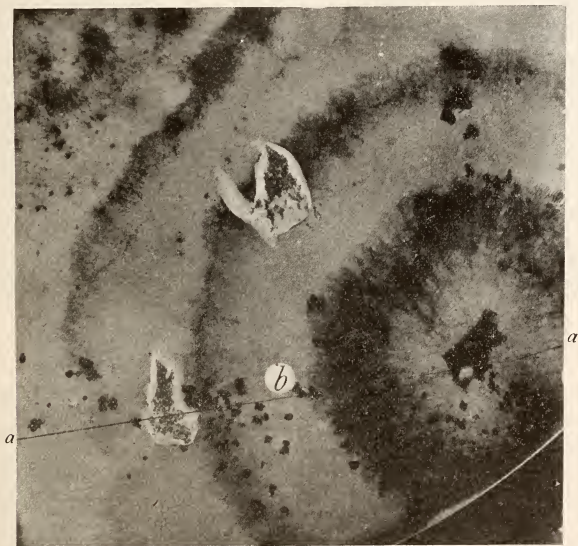


FIG. 12.—*Ascochyta Chrysanthemi* Stevens, showing abundant pycnidia on radius *a-a*, at point *b*, and paucity of pycnidia elsewhere.

When this fungus was plated from a suspension of spores two types of colony developed corresponding to the two strains mentioned above. The first "type of few pycnidia" developed a copious aerial mycelium of a loose floccose nature, extended regularly in all directions and was long devoid of pycnidia. When the pycnidia did form they were few, large and superficial (Fig. 13). The second "type of many pycnidia" had little or no aerial mycelium, all the mycelium being either immersed or of strict growth; was roughly circular in colony, not regularly so as in first type, and small, irregular, mostly immersed pycnidia were formed in myriads throughout the colony. (See Fig. 14.) These two types of colony appeared on the same plates which were in-

oculated with spores from the same pycnidium, therefore developed in the same nutrient condition, humidity, temperature, etc. Depth of planting is not the cause of these differences, since flooding the plate with an extra tube

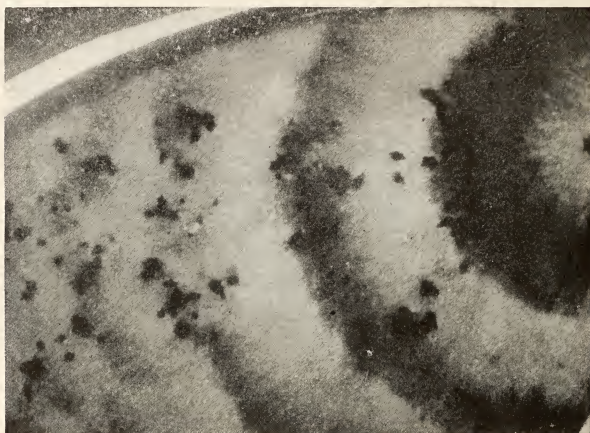


FIG. 13.—*Ascochyta Chrysanthemi* Stevens; portion of colony showing few pycnidia; cf. Fig. 14.

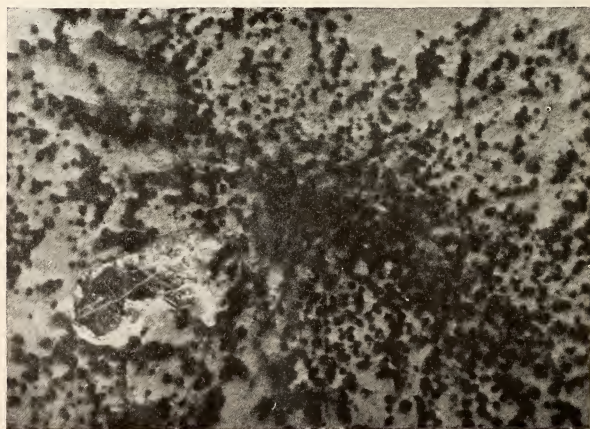


FIG. 14.—*Ascochyta Chrysanthemi* Stevens; portion of colony showing many pycnidia; cf. Fig. 13.

of agar after the agar first plated had set, did not change the proportion of the two types. Nor did sowing in such way that the spores were at the bottom rather than at the top of the agar change results. There was a marked tendency of colonies of both types of the fungus to become more productive of large pycnidia where two different colonies approach each other, suggesting that there might be needed a co-operation of two diverse strains in order to form a pycnidium; that the strains of few pycnidia lacked the requisite individuals, and that the strains of many pycnidia had more than one individual to the colony. To test this, colonies were traced from the earliest development, resulting in clear evidence that in some instances a colony developed from a single spore was one with few pycnidia; in other instances a single spore produced a colony of many pycnidia.



FIG. 15.—*Coniothyrium Fuckelii* Sacc.; portions of two colonies showing circles of pycnidia near margins.

Coniothyrium Fuckelii Sacc., from apple.

In one instance this fungus, which rarely fruited, made pycnidia in almost perfect circles near the margins of each colony on the plate. (See Fig. 15.)

These variations are inexplicable and remind one of the mysterious change from ascigerous to non-ascigerous condition so frequently met in life-history work with the imperfect fungi.

VARIABILITY IN SPORE MEASUREMENT.

Since the beginning of mycology it has been customary to give spore measurements in specific description, probably originally with the idea of

giving some information as to the approximate size of the plant concerned rather than to give exact descriptive limitations. With the advance of time, great importance has come to be attached to spore measurements—greater, perhaps, than is warranted—and many species are now founded upon divergence in this one character, and often upon slight divergence.

To ascertain the variability in spore measurement under constant conditions and its variability as occasioned by change in environment, studies with several species of fungi were undertaken.

The measurements were all made in water in which the spores had stood long enough to become fully turgid, taking only such spores as were completely ripe, as was shown by the fact that they were extruded from the pycnidium, ascus, or sporodochium, naturally, without assistance. An eye-piece micrometer was used and the units here employed are usually one division of the eye-piece scale,¹ which constituted in most cases as small a unit as could be used to advantage. Spore measurements involving half the division were recorded as with the next lower interval. To avoid any possibility of unconscious selection, the spore lying closest to contact with the end of the micrometer scale at the completion of a measurement was taken for the next measurement.

In the polygons each small square (one 256th of a square inch) represents one spore.

We wish to acknowledge our indebtedness to Dr. G. H. Shull, who has kindly read this portion of the manuscript, for calculating the constants; to Mr. B. B. Higgins, by whom most of the measurements were made and upon whose very accurate and painstaking work the value of the measurements depends.

ASCOCHYTA CHRYSANTHEMI STEVENS.

A. *Spores from the large pycnidium type* (see page 59).

Pycnidium No. 1. A large pycnidium produced in a colony which had very few pycnidia.

$$M = 4.9645 \pm 0.0393$$

$$\sigma = .9787 \pm 0.0278$$

$$C. V. = 19.714 \pm 0.581$$

$$n = 284$$

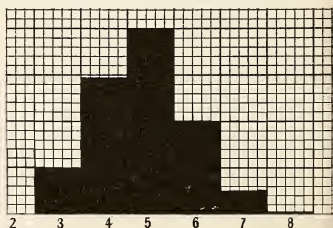


FIG. 16.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 1, large type. 3 should cover 20 squares instead of 25.

¹Division equal 3.7 μ .

Pycnidium No. 2. Large type.

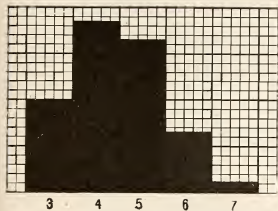


FIG. 17.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 2, large type.

$$M = 4.4318 \pm 0.0398$$

$$\sigma = .9589 \pm 0.0281$$

$$C. V. = 21.638 \pm 0.650$$

$$n = 254$$

Pycnidium No. 3. From a plate bearing one large colony. The whole colony was characteristically one of few pycnidia which were of large type and light color. The spores were obtained without any possibility of the pycnidium being torn, that is, they were normally ripe spores.

$$M = 3.3848 \pm 0.0245$$

$$\sigma = .6714 \pm 0.0173$$

$$C. V. = 19.836 \pm 0.531$$

$$n = 343$$

It is seen that these three separate pycnidia of the same type gave modes of 4.9645 ± 0.0393 , 4.4318 ± 0.0398 , and 3.3848 ± 0.0245 ; or, expressed in terms of the systematist, that in the three pycnidia the spores measured 11.1 – 29.6μ , mostly 18.5μ ; 11.1 – 25.9μ , mostly 14.8μ ; 7.4 – 22.2μ , mostly 11.1μ ; showing that measurements from one pycnidium alone are not sufficient for reliable characterization.

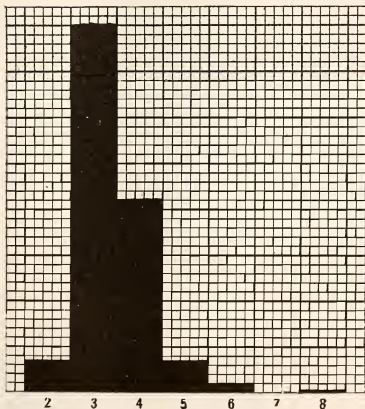
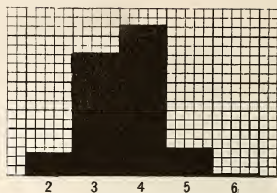
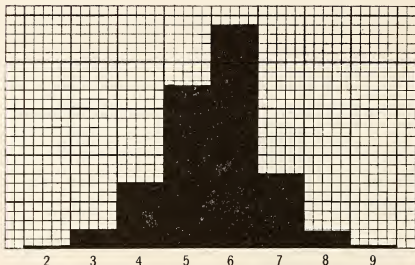


FIG. 18.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 3, large type.

B. Spores from small pycnidium type (Fig. 14).

Pycnidium No. 4. Small type.

$$\begin{aligned}
 M &= 3.6011 \pm 0.0363 \\
 \sigma &= .7183 \pm 0.0256 \\
 C. V. &= 19.947 \pm 0.740 \\
 n &= 178
 \end{aligned}$$

FIG. 19.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 4, small type.FIG. 20.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 5, small type.

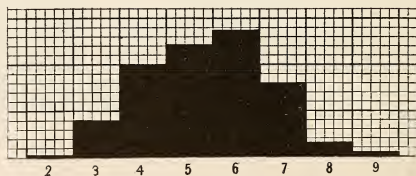
Pycnidium No. 5.

Spores taken from small pycnidium colony shown in Fig. 14.

$$\begin{aligned}
 M &= 5.5850 \pm 0.0414 \\
 \sigma &= 1.0737 \pm 0.0293 \\
 C. V. &= 19.225 \pm 0.543 \\
 n &= 306
 \end{aligned}$$

Pycnidium No. 6. A very small pycnidial type.

$$\begin{aligned}
 M &= 5.3629 \pm 0.0544 \\
 \sigma &= 1.2711 \pm 0.0385 \\
 C. V. &= 23.702 \pm 0.756 \\
 n &= 248
 \end{aligned}$$

FIG. 21.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pycnidium No. 6.

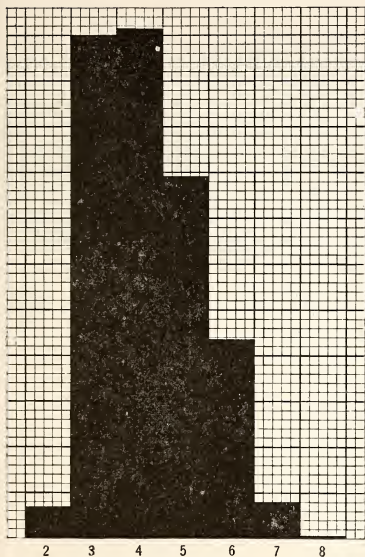


FIG. 22.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores of large pycnidia.

Collecting the data from the large pycnidium type in one polygon, and similarly with the small pycnidium type, we have:

$$\begin{aligned} M &= 4.1935 \pm 0.0247 \\ \sigma &= 1.0902 \pm 0.0174 \\ C. V. &= 25.998 \pm 0.443 \\ n &= 889 \end{aligned}$$

$$\begin{aligned} M &= 5.0379 \pm 0.0335 \\ \sigma &= 1.3492 \pm 0.0237 \\ C. V. &= 26.781 \pm 0.503 \\ n &= 738 \end{aligned}$$

It is seen that there is a tendency throughout for the smaller pycnidia to produce larger spores than are produced by the large pycnidia.

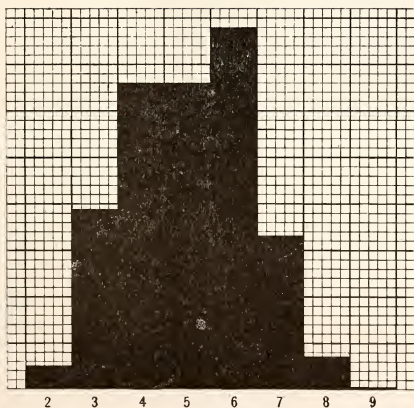


FIG. 23.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores of small pycnidia.

C. *Measurements of spores from different media.*

Pure agar. The pycnidia on this plate were very scant, although they were normal in appearance and size.

$$M = 2.6241 \pm 0.0313$$

$$\sigma = .5354 \pm 0.0221$$

$$C. V. = 20.402 \pm 0.878$$

$$n = 135$$

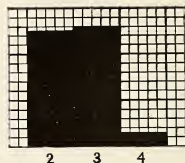


FIG. 24.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from pure agar.

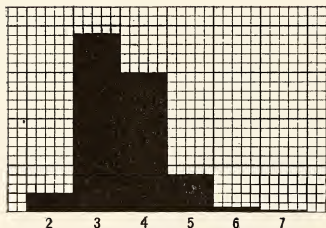


FIG. 25.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba + 0.25 per cent sodium asparaginate.

Cba + 0.25 per cent sodium asparaginate.

$$M = 3.5637 \pm 0.0358$$

$$\sigma = 0.7579 \pm 0.0253$$

$$C. V. = 21.267 \pm 0.725$$

$$n = 204$$

$$M = 5.4267 \pm 0.0356$$

$$\sigma = .7896 \pm 0.0251$$

$$C. V. = 14.551 \pm 0.459$$

$$n = 225$$

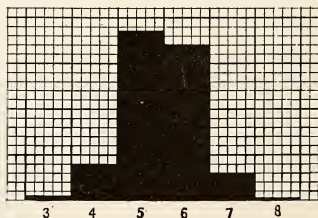


FIG. 26.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba + sodium asparaginate + starch.

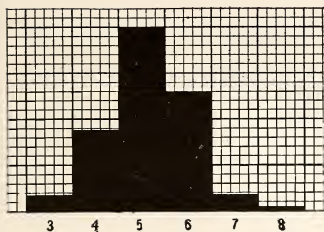


FIG. 27.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cba+sodium asparaginate+glucose.

Cba + 1 per cent glucose. This was a remarkable colony with spores distinctly smoky or olivaceous.

$$M = 5.1422 \pm 0.0408$$

$$\sigma = .9214 \pm 0.0289$$

$$C. V. = 17.919 \pm 0.579$$

$$n = 232$$

Plated thickly in 4 per cent pea agar.

$$M = 4.3246 \pm 0.0392$$

$$\sigma = 1.0138 \pm 0.0277$$

$$C. V. = 23.442 \pm 0.674$$

$$n = 350$$

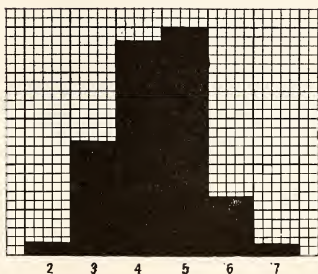


FIG. 28.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from 4 per cent pea agar.

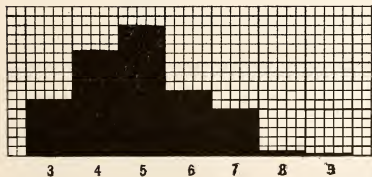


FIG. 29.—*Ascochyta Chrysanthemi* Stevens. Polygon of spores from cowpea agar.

Cowpea agar.

$$M = 4.8657 \pm 0.0545$$

$$\sigma = 1.1885 \pm 0.0386$$

$$C. V. = 24.427 \pm 0.839$$

$$n = 214$$

It is seen that on these different media the mode varies materially, being low on pure agar, higher on cba+sodium asparaginate, and still higher when glucose or starch is added. The mode is high also in natural media, such as pea agar and cowpea agar.

In the terms of the systematist, spores from pure agar measured $7.4-14.8\ \mu$, mostly $11.1\ \mu$; those from cba+sodium asparaginate $7.4-25.9\ \mu$, mostly $12.9\ \mu$.

SEPTORIA LYCOPERSICI SPEG. OF TOMATO.

Grown on apple agar.

$$\begin{aligned} M &= 21.507 \pm 0.190 \\ \sigma &= 4.686 \pm 0.135 \\ C. V. &= 21.787 \pm 0.655 \\ n &= 278 \end{aligned}$$

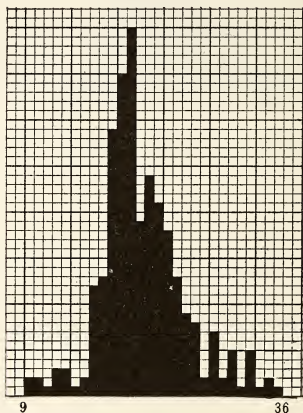


FIG. 30.—*Septoria Lycopersici* Speg. Polygon of spores on apple agar.

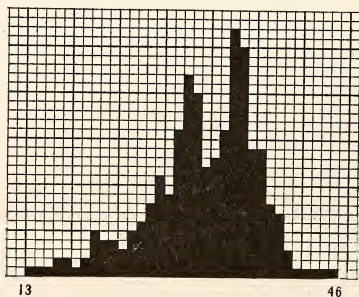


FIG. 31.—*Septoria Lycopersici* Speg. Polygon of spores on pure agar.

Grown on pure agar.

$$\begin{aligned} M &= 31.675 \pm 0.242 \\ \sigma &= 5.879 \pm 0.171 \\ C. V. &= 18.560 \pm 0.559 \\ n &= 279 \end{aligned}$$

Although the number of spores measured in the two last instances is not large, the fact of a tendency to larger spores on the poorer medium, apple agar, is evident. The spores measured $33.6\text{--}133.2\ \mu$, mostly $81.4\ \mu$, those on pure agar $48.1\text{--}181.3\ \mu$, mostly $133.2\ \mu$.

ASCOSPORES OF *SCLEROTINIA LIBERTIANA* FUECKEL.

Spores were discharged spontaneously from the disk upon the cover glass, the disk being of middle age.

$$\begin{aligned} M &= 4.0880 \pm 0.0166 \\ \sigma &= 0.2930 \pm 0.0117 \\ \text{C. V.} &= 7.168 \pm 0.290 \\ n &= 142 \end{aligned}$$

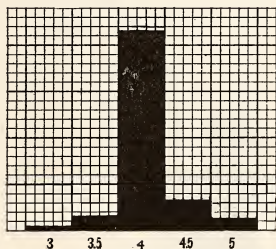


FIG. 32.—*Sclerotinia Libertiana* Fckl. Polygon of ascospores from middle-aged disk.

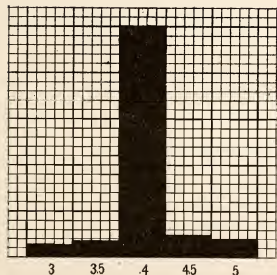


FIG. 33.—*Sclerotinia Libertiana* Fckl. Polygon of spores from young disk.

Spores were secured as in the last instance, but from very young disks.

$$\begin{aligned} M &= 4.0393 \pm 0.0214 \\ \sigma &= 0.3743 \pm 0.0151 \\ \text{C. V.} &= 9.267 \pm 0.380 \\ n &= 165 \end{aligned}$$

No material difference in the size of the spores here appeared with the change in age of the disks.

DIPLODIA MACROSPORA EARLE.

Spores of this species, isolated from corn, were grown upon pea agar.

$$M=24.362 \pm 0.176$$

$$\sigma=3.179 \pm 0.124$$

$$C. V.=13.050 \pm 0.519$$

$$n=149$$

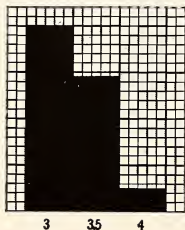


FIG. 35.—*Diplodia macrospora* Earle. Polygon of spores isolated from corn and grown upon pea agar; measurements showing thickness.

$$M=3.2595 \pm 0.0136$$

$$\sigma=.2727 \pm 0.0096$$

$$C. V.=8.367 \pm 0.297$$

$$n=183$$

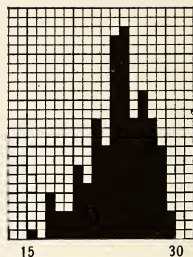


FIG. 34.—*Diplodia macrospora* Earle. Polygon of spores isolated from corn and grown upon pea agar; measurements showing length.

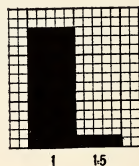


FIG. 36.—*Volutella fructi* S. and H. Polygon of spores showing width.

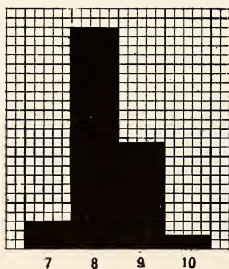


FIG. 37.—*Volutella fructi* S. and H. Polygon of spores showing length.

VOLUTELLA FRUCTI S. AND H.

$$M=8.27 \pm 0.0276$$

$$\sigma=.5778 \pm 0.0195$$

$$C. V.=6.986 \pm 0.237$$

$$n=200$$

The last five polygons are without particular significance and serve only to show the variation encountered in these forms.

GENERAL CONSIDERATIONS.

The bearing of these facts upon mycological taxonomy is apparent. If a fungus can be easily changed as regards its essential descriptive characters by a change in substratum, density of infection or other environmental factor, these characters are worthless for descriptive purposes, unless the conditions under which they develop be accurately known.

There are two fundamental requisites of benefits from description: (1) to enable recognition of a particular form; (2) to aid in classification.

The first of these is necessary preliminary to the second, and it is with mere recognition that we have in many instances yet to deal in mycology, particularly among the group *Fungi imperfecti* with its enormous genera, such as *Septoria* and *Phyllosticta* and *Cercospora* with their thousands of so-called species. While life-history work and infection experiments will do much, accurate recognition of the form in hand is a necessary preliminary even to this.

To reach any satisfactory basis, many fungi must be studied in culture much after the fashion that bacteria are now studied.

CARNATION ALTERNARIOSE.¹

BY F. L. STEVENS AND J. G. HALL.

To a leaf and stem disease of the cultivated carnation, *Dianthus Carophyllus* L., our attention was called by local florists as causing serious damage. The disease, upon examination, proved to be one hitherto undescribed, and a laboratory study of it was undertaken.²

SYMPTOMS.

The disease manifests itself as spots, mostly upon the leaves, sometimes upon the stems, especially at the nodes. These spots are strikingly characteristic, of ashen whiteness, with the center occupied by an often scanty, though sometimes profuse black fungous growth. The diseased spot is dry, somewhat shrunken, thinner than healthy portions of the leaf, approximately circular, though often somewhat elongated in the direction of the longitudinal axis of the leaf. (Fig. 38.) When occurring at the node, the disease usually involves the bases of both of the leaves, as well as the stem between them. (Fig. 38, 2.) As these nodal spots age the disease penetrates through the stem, killing its tissue, which shrinks somewhat and becomes soft and disintegrated, resulting in death of the more distal portions of the plant.

VARIETY OF CARNATIONS AFFECTED.

A striking feature of this disease is its tendency to infect to a large degree one variety of plant, the Mrs. Thomas W. Lawson, to the exemption of others. In all cases which have come to our notice it has been this variety solely which was diseased; moreover, the only records that we find of the disease imply the same susceptibility.³

CAUSAL FUNGUS.

Throughout the diseased tissue of all spots occurs in great abundance a characteristic, dark, branching, septate mycelium (Fig. 40, 3). The surfaces of diseased spots in periods later than their earliest youth present an abundance of black cespitose hyphae arising from the stomata (Fig. 40, 4). Spores of the *Alternaria* type are found in abundance, Figs. 40 (5) and 40 (6), both *in situ* upon these hyphae, and strewn over the surface of the diseased spots between the hyphal bases. The character and arrangement of the hyphae is shown in Figs. 40 (7) and 40 (8). This fungus was constantly associated with the disease, and no other fungus was found. The presumptive evidence was therefore very strong that this fungus was the cause of the disease. In view of the often saprophytic habit of *Alternaria*, conclusions on this point would not be valid without evidence from inoculations.

¹Printed in the Botanical Gazette, 47, No. 5, May, 1909.

²Through the kindness of Dr. Orton, U. S. Department of Agriculture, we learn that a *Macrosporium* disease of carnation was reported from Strassburg, Pa., in 1906, and one attributed to *Alternaria* from Connecticut by Clinton in the same year.

³Orton, Year-book U. S. Dept. Agr., 1905, p. 611.



FIG. 38.—(1) Single leaf showing diseased spot near base. (2) Diseased plant showing removal of lower leaves by the gardener in his efforts to stop the progress of the disease.

INOCULATIONS.

The fungus was easily isolated by direct transfer of spores from the diseased spots to carnation leaf agar plates.

On October 27 numerous inoculations were made upon two plants under bell jars, using small pieces of agar, bearing spores and mycelium. One of the plants was left uninjured and the inoculum was placed in the axils of the leaves; in the majority of these cases the inoculations resulted in infection. The other plant was injured by the prick of a needle at the point

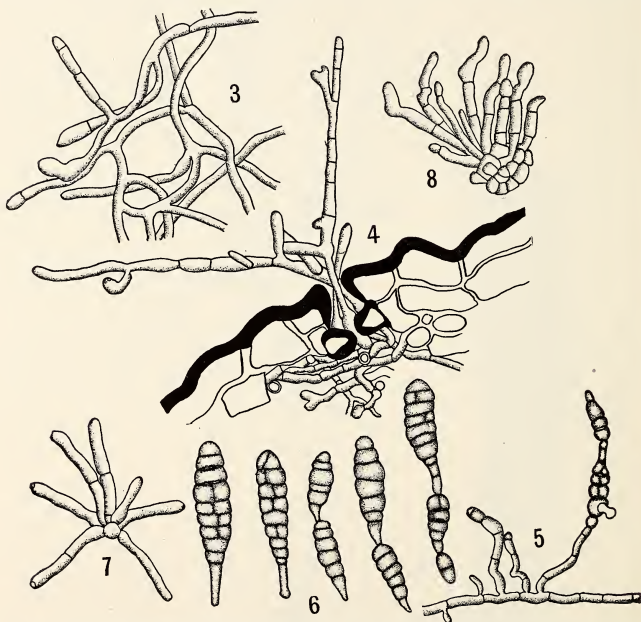


FIG. 40.—(3) Mycelium showing branching and septation. (4) Showing mycelium below stoma and hyphae emerging through the stoma. (5) Showing catenulate spores as borne upon hyphae. (6) Spores showing shape, septation and catenulation. (7) A young cluster of hyphae. (8) An older cluster of hyphae.

of inoculation. In these cases about two-thirds of the inoculations were successful. Inoculations with spore suspension were also made upon five branches each, of two other plants, and each was covered by a large test tube plugged around the stem with cotton to preserve a humid atmosphere. As in the former cases, the inoculations on one plant were at injured points and those on the other plant were at uninjured points. The results from these spore inoculations were the same as in the cases of inoculations with agar blocks. When these inoculations were made, others were made upon six other plants

from the same spore suspension, but the plants were not covered or injured in any way. Following these last inoculations no signs of the disease were seen. It seems from these experiments that the injured plant is readily susceptible to infection, as is also the uninjured plant if kept in humid condition, but that the uninjured plant in a relatively dry atmosphere is difficult or impossible of infection. In case of successful inoculation the diseased spots were well developed at the end of a week. The removal of the protecting bell jar from plants already infected resulted, usually, in cessation of development of the spot. These facts agree well with the field observation that the most damaging infection occurs at the leaf axils, points well adapted to collect and hold water, thus providing conditions for optimum development of the fungus.

CULTURE CHARACTERS.

The fungus was grown upon many different media. Its characters upon these media have been noted elsewhere.³ The most important culture characters may be summarized as follows:

Upon media poor in available carbohydrates the mycelium was nearly hyaline and the hyphæ and spores pale; upon media rich in carbohydrates mycelium, hyphæ and spore were very dark. Upon the natural medium the spores were more regular and uniform in shape and were much larger than upon artificial media.

SPECIES OF THE FUNGUS.

Of the *Alternarias* there seems to be only one, *A. longispora* McAlph, growing upon members of the pink family (*Caryophyllaceæ*), (Sacc. Syll. Fung., 18:638), and the description of this does not agree with ours in size, shape, or septation of its spores.

Therefore, unless an attempt be made to identify this form with some one of the seven or more species of *Macrosporium* infecting the pink family—a procedure which would be unjustifiable without resort to cross-culture inoculations and extensive study in artificial media—this form had best be designated as a distinct species, for which we propose the following name and description:

Alternaria Dianthi n. sp.

Hyphæ cespitose from stomata, amphigenous, dark brown, 1-4 septate, ascending, 1-25 from each stoma; conidia 26-123 x 10-20 μ catenulate, clavate, tapering to pedicel, base obtuse, dark brown, transverse septa 5-9, longitudinal septa 0-5.

Spot ashen white definite, subcircular.

On artificial media poor in carbohydrates color of mycelium and spores lighter, smaller and with fewer septa.

Habitat: Living leaves and stems of *Dianthus Carophyllus*, Raleigh, N. C.

³Stevens and Hall, Variation in Fungi Due to Environment, Bot. Gaz. 48, July, 1909.

HYPOCHNOSE OF POMACEOUS FRUITS.¹

BY F. L. STEVENS AND J. G. HALL.

A disease which from its most prominent symptoms may popularly well be called the *leaf blight* and which may technically be designated as *Hypochnose*, has been under observation and study by the authors several years, as affecting the apple, pear, and quince. During this time it has been frequently referred to the Experiment Station for diagnosis and treatment, and it seems to be one of the worst diseases occurring on neglected trees in the humid portions of the State.

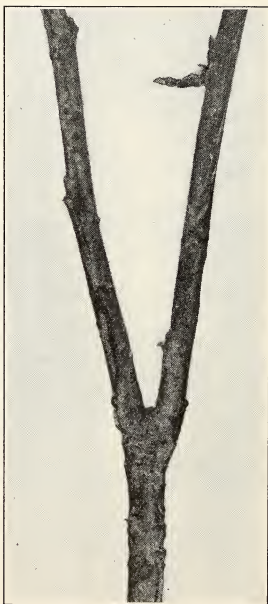


FIG. 41.—Sclerotia and rhizomorphic mycelium upon apple twigs; natural size.

SYMPTOMS.

Viewed from some distance, trees in early stages of *Hypochnose* appear much as do trees affected with the ordinary fire blight (*Bacilliose*) caused by *Bacillus amylovorus* (Burrill) De Toni, that is, the leaves on numerous

¹Printed in *Annales Mycologici*, Vol. 7, No. 1, 1909.

twigs throughout the trees are dead. Differing from *Bacilliose*, however, the leaves instead of standing erect, usually droop, hanging down in dense, matted masses. The affection, too, is limited to the leaves, the twigs themselves not dying as in the case of *Bacilliose*. The resemblance is very striking, and to the casual observer *Hypochnose* would doubtless pass for the widespread, well-known "fire blight."

In later stages of the disease most of the affected leaves fall away and the similarity to *Bacilliose* disappears, the tree now attracting attention chiefly by its scant equipment of leaves. Closer inspection of the twigs with the affected leaves shows each of them to bear two characteristic structures:



FIG. 42.—Sclerotia on apple twigs, enlarged.

1. Roundish or oblong sclerotia, usually 3 or 4 mm. in diameter, which are clearly shown on the left-hand branch in Fig. 41, and somewhat enlarged in Fig. 42.

2. Mycelial ribbons, rhizomorphic structures extending lengthwise of the twigs and petioles. (Fig. 43.)

The sclerotia originate as white masses of interwoven mycelium, which when mature become rich chestnut brown in color. They are formed in great abundance upon the twigs of the current year, especially upon the lower, shaded, damp side, but very sparingly or not at all upon the petioles

or leaves. On two-year-old twigs the sclerotia are darker in color, shriveled and sometimes cracked, and it is doubtful if they live longer than through the summer following their origin. Upon badly affected trees it is possible to find sclerotia upon older twigs, two, three, four, or five years old, the size of the sclerotia being diminished by waste, shrinking, and weathering, with the age of the wood upon which they rest. Sclerotia are sometimes found upon fruit, though much less frequently than upon twigs.



FIG. 43.—Rhizomorphic mycelium upon apple twigs and petioles; weft of floccose mycelium on inferior surface of leaf.

The mycelial rhizomorphic structures when young are white, but as they age they rapidly assume a characteristic glistening brown appearance. They extend in a general longitudinal direction, and usually remain unbranched between the nodes, though they sometimes branch and anastomose, forming a small plexus. Occasionally branches diverge to courses leading around the twig. At the base of each small twig the ribbon usually branches, a portion of it passing onto the smaller twig.

Branches of these mycelial ribbons also follow up the petioles and the main veins of the leaves, eventually spreading out, separating into single

mycelial threads and becoming lost to the naked eye. The mycelial ribbons on the older wood die and often weather away, though they adhere with considerable persistence.



FIG. 44.—Apple twig showing characteristic matting of dead leaves held together by dense growth of mycelium; twigs and leaves densely covered by mycelium and sclerotia.

Upon the under surface of affected leaves may be found usually a more or less dense reticulum of mycelial threads. In some instances this web consists of a dense mat of threads, white or fuscous according to their age (Fig. 43, lower left-hand leaf), in other cases the network may be so sparse as to be imperceptible to the naked eye.

In all cases there is organic connection between this network on the leaf and the mycelial ribbons traversing the petiole. These ribbons are seen under the microscope to fray out and become dissipated over the under leaf surface.

The organic connection between the reticulum on the leaves, the mycelial rhizomorphic strands, and the sclerotia is established clearly and beyond doubt.

In some cases, comparatively rare, the weft on the lower surface of the leaf takes on more even texture, different from the tangled heaps more often found. In this condition the weft can be stripped from the leaf like a false epidermis. This is the sporogenous part of the fungus.

The twigs bearing the fungus do not die from its presence. They seem to be injured only indirectly through the effect of the fungus upon the leaves.

Leaves bearing the fungus turn brown and die. Since they droop in dying, they thus often come in contact with other leaves and the fungus is afforded a ready means of migration to the new victim, which in turn rapidly succumbs. If humid conditions prevail, the fungus grows with great rapidity and vigor between the matted masses of leaves, thus resulting in fastening the dead leaves somewhat firmly together and furnishing one of the distinguishing characteristics of the disease. (Fig. 44.)

FUNGUS.

The mycelial ribbons, which may be termed the *migratory mycelium*, to distinguish it from the vegetative and fructifying mycelium, consist of more or less parallel mycelial threads very uniform in diameter, about $5.8\ \mu$, comparatively thick, walled and rigid, of characteristic glistening, smooth surface, white when young, tawny or buff when old, and nearly or quite devoid of protoplasmic contents. These threads are septate at intervals of about $40\text{--}120\ \mu$, and branch rather infrequently. The branches originate usually at right angles to this mother strand, but almost immediately bend to assume a direction parallel to the main ribbon. No clamp connections were seen.

A section of the sclerotia reveals them as compactly woven masses of swollen irregular hyphae. They are entirely devoid of any special epidermal structure, false epidermis, or rind, the peripheral structure being identical with that of the interior.

The sporogenous reticulum is of very close, irregular mesh of hyphae of varying thickness, readily distinguished from the migratory mycelium, a single thread of which is occasionally seen across the field, by its thinner wall, greater irregularity of shape and size, and by its richness of protoplasmic content. Arising from the hyphae of this reticulum are numerous thickened swollen branches which prove to be the basidia, bearing four slender sterigmata which bear the four spores. (Fig. 45.)



FIG. 45.—Basidia, sterigmata and spores.

The spores are oblong, slightly flattened on the side adjacent to the companion spore and taper slightly at each end. They are very uniform in size,

4.7-5.8 x 10.5-11.6 μ . Of thirty-eight spores measured, thirty were of the larger dimension given and eight of the smaller dimension.

When stored in humid atmosphere, as in a culture dish, for a day or so, the fungus grows luxuriantly, producing great quantities of cotton-like mycelium. (Fig. 44.) The fungus was seen to spread 1 cm. in every direction from the point of contact in two and one-half days, when leaves bearing the fungus in this vigorous vegetative condition were placed in contact with healthy leaves in the moist chamber. Specimens wrapped to mail, when wet from rain, produced voluminous growth in forty-eight hours, many leaves becoming matted together, others becoming completely covered with the cotton-like mycelium and fringed on the edge with a border of mycelium reaching out for more victims.

The development of the fungus in early spring has not been studied, but it is clear that the sclerotia are hibernating structures and that in spring they serve as the initial points for new invasion. The spread of the fungus from point to point is chiefly by means of the rhizomorphic structures, which serve the purpose so admirably that by midsummer the uppermost buds are reached and already overlaid by sclerotia ready to carry on the invasion again another season. The work of the sclerotia is so completely done that rarely, if ever, does the parasite allow the escape of any of the branches originating from a twig upon which the fungus has established itself. Unless saved by outside aid, to be once infected is to be always infected.

A beautiful adaptation is noted in that the formation of sclerotia is abandoned on leaves where they would be of but minor importance, perhaps of no use at all, and is carried to a maximum upon twigs, particularly the most distal ends of the twigs, where they are of maximum utility in the perpetuation of the species.

The perfection of vegetative methods of reproduction has lessened the value or necessity of spore formation, a fact which perhaps explains the comparative rarity of fructification in this fungus.

THE FUNGUS IN NORTH AMERICA.

While the spore-bearing structures of this fungus were not seen, and consequently its classification was not known in America until 1907,¹ its sclerotia and rhizomorphic structures have several times come to the attention of mycologists in the United States. Thus Atkinson writes us that he believes he had the same thing sent him when he was connected with the Alabama Station.

Burt writes in private letter that the sclerotia were known to him, but he did not receive the fructification. He also states that specimens of the sclerotial stage have been referred to him on living twigs of apple, and on pear twigs.

Farlow says that sterile parts of the fungus have several times been referred to him. The sterile parts of this fungus and the destructive effects of it were noted by Quaintance with photographs and with the statement² that the fungus is known in Florida and Georgia, and that in one case it constituted for several years the most destructive fungus in the orchard.

¹STEVENS, Two Interesting Apple Fungi, Science, n. s. 27, p. 724.

²Ga. Sta., 13th Rpt., 1901, p. 359.

Earle states in private communication that the fungus was sent to the Alabama Station several times from Florida and Georgia while he was connected with it.

What was probably the same fungus was also mentioned by Sheldon as occurring upon apple, pear, and plum twigs, and by hearsay upon currant, gooseberry, and cherry in West Virginia.³

Collections in North Carolina have been made on the apple at Horseshoe, Addie, Franklin, Hayesville, Marshall, Murphy, Robbinsville, Sylva, Bryson City, Fatima, Newton, Eufola, Mount Airy, Spruce Pine, Rutherfordton, Chimney Rock; on the pear at Sylva, and on the quince at Horseshoe.

Collections of spore-bearing material were made at Mount Airy, Spruce Pine, and near Rutherfordton.

IDENTITY OF THE FUNGUS.

This fungus in all of its remarkable characters agrees with the description of *Hypochnus ochroleucus* Noack,⁴ published by Noack as *Hypochnopsis*, a fungus which was found by Noack in the State of Minas Geraes, Brazil, on apple and quince trees, and which was supposed to be the cause of a diseased condition of the leaves. Noack says in part that the apple trees and quinces attacked by this fungus were brought to his attention by the dryness of many leaves. "Examined more closely, one sees fine, shining strands, white or ochre color, on the branches, often in spiral or elongated spiral lines. They approach the pedicels of the leaves, follow up the same, spread over and cover the lower side of the leaves with a very fine net of hyphæ. A few of these hyaline hyphæ end in corrolloid branches fastened strongly to the skin of the leaf and serve, doubtless, for the purpose of attaching the fungus to it. * * * The attacked leaves wilt and dry altogether, but they can remain on the trees a long time, adhering together in a confused mass, attached to the branches mainly by the tenacious threads of the mycelium. * * * Unfortunately, we are lacking its fructification, and for that reason its classification is doubtful. But we can find a very similar fungus belonging to the family of *Hypochnaceae* in the forest around Campinas, and therefore we call it provisionally our *Unknown Hypochnopsis*."

While it has been impossible to find specimens of Noack's fungus in any of the Brazilian or European herbaria, there seems to be no doubt of its identity with the form under discussion.

DISTRIBUTION.

This disease prevails generally throughout the mountain section of North Carolina; and that it is not limited to the mountains is shown by the fact that specimens have been sent to us from the coastal plain region with complaints of damage. (Fig. 46.) From the observations of Atkinson, Earle, Quaintance, and Sheldon, its presence is known in the mountains of West Virginia and in Alabama, while the observations of Farlow and Burt indicate its much more widespread existence.

³W. Va. Sta. Rpt., 1905-06, p. 31.

⁴Saccardo, Sylloge Fungorum, 16, p. 197.

⁵Boletim do Instituto Agronomico do estado de Sao Paulo Em Campinas. 9, 1898. Marco Numero 1, Sao Paulo, Brazil.

Our own observation, agreeing with those of Noack in Brazil, show the disease to occur with much greater destructiveness in humid localities, such as the mountain valleys where the dew is excessive and morning fogs prevail, and it seems probable that this disease is of wide distribution where these conditions obtain.



FIG. 46.—Map of North Carolina; shaded counties are those in which disease occurs.

PROPHYLAXIS.

The fungus, wintering in a purely superficial manner upon the twigs and depending to but a slight degree upon spores, will probably give way to thorough spring sprayings. The fact that the disease has not been noted upon sprayed orchards indicates the efficiency of such treatment.

PARASITISM OF *HYPOCHNUS* AND *CORTICIUM*.

These genera, which are difficult to separate and which by many are considered as identical, are in the main saprophytes, yet several cases of parasitism have been attributed to them. Among the parasitic forms Frank⁶ in 1895 recognized only two as belonging to the genus *Hypochnus*, viz., *H. Solani* P. & D., noted on potatoes as early as 1891,⁷ and *H. cucumeris* Frank,⁸ which was noted as the cause of a cucumber disease in 1883 and later on lupine and clover. *H. filamentosus* Pat. has since been described as growing upon live leaves of *Caryophyllaceæ* and *Amaryllidaceæ* in Quito, and Eustace has recently discussed a species of *Hypochnus* as causing a decay of stored apples.⁹

H. Gardenia, Zimm., described by Zimmerman,¹⁰ closely resembles the species in hand in the formation of ribbon-like strands on the twigs, which then extend to the lower sides of the leaves and develop a sporogenous layer; also in the structure of its fruiting portion.

H. Hellebori Rostr. is noted as a parasite upon *Helleborus niger* by Rostrup.¹¹

H. fuciformis (Berk.) McAlp. grows parasitically upon Australian grasses in very destructive form.¹²

In the genus *Corticium* as parasites we find the following:

C. confluens Fries, noted by Jaczewski as a facultative parasite preying upon *Caragana*.¹³

⁶Die Krankheiten der Pflanzen, 2, p. 219.

⁷Soc. Myc. Fr. 8, p. 221.

⁸Hedwigia 18, p. 127.

⁹N. Y. Sta. Bul. 235.

¹⁰Centbl. Bakt. II, 7, p. 102.

¹¹Ztschr. Pflanzenkrankh., 9, p. 47.

¹²Ann. Mycol., 4, p. 541. McAlpine, A New Hymenomycete.

¹³Ztschr. Pflanzenkrankh., 10, p. 341.

C. vagum B. & C. var. *solani*, which has been identified by Rolfe as the fruiting form of *Rhizoctonia*.¹⁴

C. javanicum (P. Henn.) Sacc. & Syd. on *Coffea*, *Thea*, *Bixa*, described as the cause of disease by Zimmerman.¹⁵

Associated with this fungus are sclerotia, probably genetically connected with it. Disease caused by the fungus upon a large number of other plants is mentioned by Zehntner.¹⁶

C. dendriticum P. Henn. is noted by Hennings¹⁸ as a parasite on orange stems.



FIG. 47.—Quince branch and single leaf, showing sclerotia and mycelial masses.

ADDENDUM.

Since the preparation of the above article this fungus has come to our attention upon two new hosts, and collections on old hosts have been made in several new localities, as is indicated on next page.

¹⁴Col. Sta. Bul. 91.

¹⁵Centbl. Bakt. II, 7, p. 102.

¹⁷Ztschr. Pflanzenkrank, 18, p. 45.

¹⁸Centbl. Bakt. II, 9, p. 939.

On Apple.

Robbinsville	August 6, 1909.....	F. L. Stevens.
Murphy	August 9, 1909.....	F. L. Stevens.
Hayesville	August 10, 1909.....	F. L. Stevens.
Eulalie	August 14, 1909.....	F. L. Stevens.
Leicester	July 17, 1909.....	B. B. Higgins.

On Quince. (Fig. 47.)

Eulalie	August 14, 1909.....	F. L. Stevens.
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On Snowball (Viburnum).

Eulalie	August 14, 1909.....	F. L. Stevens.
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On Lilac (Syringa vulgaris).

Eulalie	August 14, 1909.....	F. L. Stevens.
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In many sections of Western North Carolina the fungus was so prevalent as to be found on nearly every tree seen, and whenever present the disease was always of extremely destructive character, resulting early in complete defoliation.

The fungus on the Snowball (Viburnum) :

Only one collection was made on this host (though what was supposed to be the same was glimpsed on other occasions), and then in a valley where the fungus grows with especial luxuriance upon its more usual hosts. The disease caused upon this host agrees in every particular with that upon the apple, except that as the leaf collapses under the attack of the fungus the mycelium accumulates in much more dense masses upon the under surface of the leaf. (Fig. 48.) This difference in habit may be due to the thinner texture of the leaf which



FIG. 48.—Leaf of Snowball showing white masses of mycelium.

allows it to fall into folds, thus producing regions of especial moisture and forming more vigorous growth of mycelium.

Fungus on Lilac (Syringa vulgaris) :

Only one collection was made upon this host, and this in the same yard where the fungus was found upon apple, quince, and snowball. The characters of disease produced were almost identical with those upon the apple. No such development of loose mycelium appeared as upon the snowball, probably owing to the stiffness of the leaf.

NEW FIG ANTHRACNOSE¹ (COLLETOTRICHOSE).

BY F. L. STEVENS AND J. G. HALL.

A fig disease, the chief symptoms consisting of rotting and premature fall of the fruit, has come to our attention from the eastern part of North Carolina. The disease begins before the fruit commences to ripen, as small specks of rot on the fruit surface. Such rotten specks are usually very numerous, from five to thirty-five or more on each fig. The spots are soft, watery in appearance and definitely bordered. At their centers they are brownish and



FIG. 49.—A single fig somewhat enlarged, showing white floccose mycelium around and over the spots.

slightly sunken. The spots enlarge rapidly and very soon the central region of each is occupied by numerous small, moist, pinkish to salmon colored pustules, each less than a millimeter in diameter.

The affected fig rapidly assumes a rotten appearance, loses its firmness, becomes watery, shrivels, and is soon almost entirely covered with the spore-bearing pustules. If under humid conditions, the spots become bordered and covered with a more or less dense growth of aërial, floccose, white hyphæ, which are sometimes so abundant as to produce a dense mat either over or surrounding the spot. This condition is shown in Fig. 49 somewhat enlarged.

¹Presented at the December Meeting, 1908, of the A. A. A. S. Published in part in *Zeitschrift f. Pflanzenkrankheiten* 19, p. 65.

In later stages of decay the fig is usually invaded by a large number of saprophytic fungi, usually predominated by dark green or black.

The fruit usually falls early in the decay. The disease prevails to such an extent that an affected bush may fail each year to mature its fruit, though setting fruit in abundance. The leaves of the affected bushes are also often diseased, turning brown, shriveling at the edges, and dying. The rot resembles that of the apple (*Glomerellose*) and the spots in a general way resemble the disease spots of the cotton anthracnose (*Colletotrichose*) or that of the bean or watermelon.

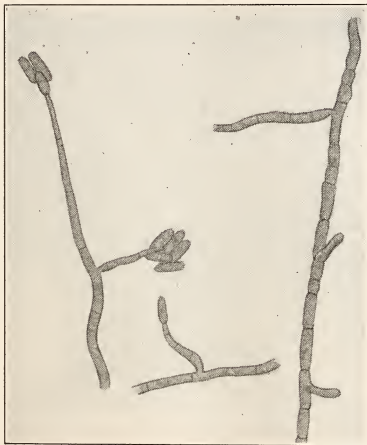


FIG. 50.—Showing mycelium, septation, branching and spores formation.

CAUSAL FUNGUS.

The diseased spots upon the fruit are always occupied by a species of *Colletotrichum*, which from the abundance of its spores seen *en masse* gives the pinkish color to the center of the disease spots.

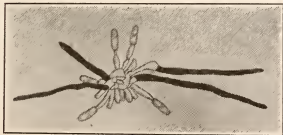


FIG. 51.—Portion of an acervulus showing conidia, conidiophores and setae.

The mycelium is slender (1.5 to 6 μ in diameter), hyaline, much branched and sparingly septate. The branches in artificial culture arise at almost right angles from the parent branch (Fig. 50). The characteristic, greenish black appressoria of the anthracnoses are found.

The small, numerous hemispherical acervuli are brown to black until that color is obscured by the pinkish spores.

The setae (Fig. 51), which may number from one to twelve, or which in

many instances are entirely absent, are long, irregular, slender, tapering toward an acute point. They are dark colored throughout, rigid, septate.

The spores are regular, oblong, continuous with obtuse ends, borne upon slender hyaline conidiophores. The spores germinate very readily in almost any medium, sending out from one to three germination tubes each.

The fungus was very readily isolated by planting a suspension of spores from figs, as they came into the laboratory, in 4 per cent pea agar. These cultures produced great quantities of acervuli, from which, by replating, characteristic pure cultures were obtained. These were used for inoculations in both laboratory and field.

INOCULATIONS.

In the laboratory two methods of inoculation were followed: 1. Spores were rubbed upon the surface of the fruit. 2. The fruit was pricked with a sterile needle and the spores introduced into the injured spot. In both cases the spots characteristic of the disease were produced a day or two later, the fruit being kept in a culture chamber.

In the field a suspension of spores in water was sprayed upon a bush in fruit. Fifteen or twenty days afterward no indication of infection was apparent, but specimens showing no lesions when placed in sterile culture dishes in the laboratory, developed Colletotrichose after a few days in great abundance. Eight figs, placed in culture dishes, autoclaved, then inoculated, all showed the mycelium characteristic of the disease at and around the point of inoculation, the mycelium being much more abundant upon these sterilized figs than upon those not sterilized. In due time the salmon-colored spores of the disease appeared in numerous pustules on both sterilized and unsterilized fruits.

Further field inoculations made with an enclosed, moist atmosphere, September 26, 1908, showed rotten spots on October 1, although no fungus was visible. The fruit, all of which had fallen from the bush, was placed in sterile culture dishes in the laboratory, and at the end of three days all specimens showed the characteristic disease, and at the end of a week great masses of spores were visible.

It is clear from the inoculation experiments that this fungus will grow upon the fig, sterile or in natural condition, if in a humid atmosphere, but that it does not grow well upon raw figs in a dry atmosphere.

These results are in accord with our observations upon the distribution of the disease, which has been noted as yet only in exceedingly humid localities, as on our seaboard.

IDENTITY OF THE FUNGUS.

Upon the genus *Ficus* we find recorded four species of *Colletotrichum* and four species of *Gloeosporium*, which are as follows, with the host plants indicated:

1. *Colletotrichum elasticae* F. Tassi, in leaves of *Fiscus elastica* Italy.
2. *Colletotrichum elasticae* Zimm., in leaves *F. elastica*. Koorders says this is identical with *C. elasticae* F. Tassi.²
3. *Colletotrichum Fici-Elasticae* Zimm., in leaves *F. elastica* Java.

²Botanische Untersuchungenuber einige in Java vorkommende Pilze, besonders uber Blatter bewohnende, parasitisch auf tretende arten (Verh. Von. Akad. von Wetensch te Amsterdam Tweede Sect. Dert. XIII 4, p. 264), also (Notizblatt d. Konig Bot. Gart. u. Mus. zu. Berlin-Dahlem, No. 40, Bd. IV, 1907).

4. *Colletotrichum Fiscus*³ Koord.

5. *Gloesporium intermedium* Sacc. var. *brevipes* on leaves of *F. elastica*. Koorders says this is indistinguishable from *G. elasticæ* C. & M.

6. *Gloesporium elasticæ* C. & M. on leaves of *Fiscus elastica*.

7. *Gloesporium Beniaminæ* Scalia on leaves of *F. Beniaminæ* in Sicily.

8. *Gloesporium fructigenum* Berk. in fig fruits, Sussex, England, 1864.⁴

Only one of these species is recorded as occurring upon the fig, *Ficus Carica*, itself, nor do any of these species seem to be the species found upon the fig in this State.

Aside from the presence of setae in the species under discussion, it also differs from each of the various species of *Gloesporium*. Its spores are smaller than those of No. 5 and its basidia are narrower and shorter. Its spores are much smaller and of very different shape than those of No. 7. Its spores differ in shape and size from those of No. 6 and are smaller than those of No. 8.

This species differs clearly from each of the species of *Colletotrichum* also. Its setae are much shorter than those of No. 3, which also is separated from it by its crescent-shaped spores. It is distinguished from Nos. 1 and 2 by its shorter setae and smaller uncurved spores.

It is possible that this disease is the same referred to as an undescribed *Colletotrichum* in the Year-book of the U. S. Department of Agriculture, 1907, p. 581, or that it is identical with a *Colletotrichum* of fig fruit collected at Berkley, Va., in 1905 and thought by Mrs. Flora Patterson to be an undescribed species, though it is impossible in the absence of any description or specimen to be sure in this regard.

It seems desirable to recognize this as a new species of *Colletotrichum*, for which we propose the following name and characterization drawn from the fungus as growing upon the nearly ripe fig:

Colletotrichum Carica, n sp.

Acervuli brown, becoming black, hemispherical, numerous, small, 85 to 250 μ in diameter, bearing one to twelve or often no setae, setae long, irregular, slender, acute, dark throughout, rigid, septate, 2 to 6 μ , thick by 22 to 106 μ long; conidiophores, slender 1 to 2 μ wide, 45 μ long hyaline; spores, regular, oblong, obtuse, continuous, hyaline, 3.5 to 6.6 μ by 8.7 to 20 μ .

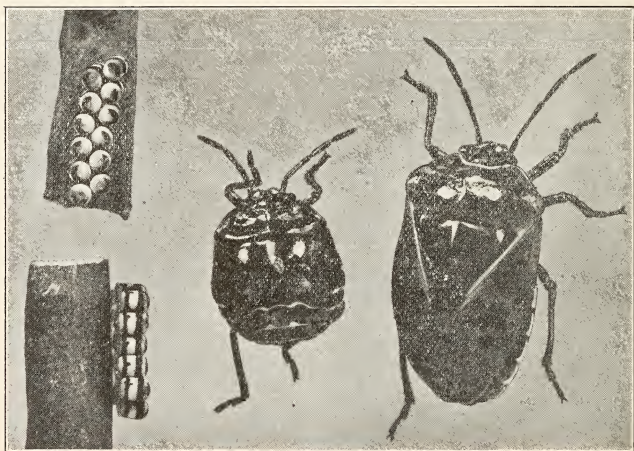
³Now regarded as *Neozimmermania Elasticæ* (Koorders, Bot. Unt Verh of Koninklijke Akad. v. Wetenschappen te Amsterdam Dert. XIII, No. 4, 1907).

⁴Cooke, Jour. Roy. Hort. Soc., 28, p. 29.

HARLEQUIN CABBAGE BUG (*MURGANTIA HISTRIONICA*).¹

BY R. I. SMITH.

As an enemy of collard, cabbage, turnip, and related plants throughout the Southern States, none surpasses the harlequin bug in persistence and general destructiveness, in spite of the numerous remedies that are constantly printed in bulletins, agricultural papers and journals. The general failure to control this pest is partly the result of neglect, but is due largely to the farmers' lack of information concerning how the insect feeds, its rate of increase and remarkable power of surviving under unfavorable conditions. Realizing this



situation, the writer undertook, in 1908, a thorough study of the life-history and habits of this insect with a view to determining definitely the best methods of control. The results of this work, recorded in the following pages, reveal some facts hitherto unknown, which furnish a sound basis for the remedial suggestions which are made a part of this article.

Examination of the literature shows that some early writers make very erroneous statements concerning the number of annual generations and rate of increase. Later writers have frequently repeated these questionable statements, and, in general, entomologists have failed to make definite and complete observations on the most vital points in connection with this insect's life-history and habits. The writer's studies, although not complete in every

¹Terrapin bug, collard bug, fire bug, calico bug, and sometimes other names of local adoption, are applied to this insect; but harlequin cabbage bug is the name by which it is most widely recognized in the various States where it occurs.

respect, have resulted in obtaining information of considerable economic importance, because they show how and why the pest may be controlled by hand-collecting, spraying, and correct cultural methods.

DESCRIPTION.

The illustration shows the general appearance of eggs, young and adults. The latter have well-developed wings, with the dark portions black or metallic blue, and the lighter portion bright yellow in freshly transformed bugs, and red in the older individuals. The younger stages lack wings and vary somewhat in shape and appearance, in accordance with their age, but are readily recognized.

The eggs are set on end in masses of ten to fourteen, and resemble miniature barrels bound with two black hoops, as shown in the illustration.

GENERAL LIFE-HISTORY AND HABITS.

Winter Stage.—Harlequin cabbage bugs pass the winter in this state only as strong, mature adults, protected by whatever cover they happen to find. It seems probable that most of the bugs seek shelter in the fields where they were last feeding, but many find more favorable hibernating quarters under fences, buildings, rubbish piles, and in adjoining woodlands or thickets. A large number of the bugs that seek winter protection are unable to secure a favorable place, and consequently die, but a sufficient number survive, as is evidenced by their abundance each spring.

Eggs deposited in the fall too late to hatch, or bugs that fail to reach maturity before winter commences, do not live until spring.

Earliest Appearance.—The first warm spring days find the bugs issuing from their hiding quarters, and they may become active during a prolonged warm period in winter, but in 1908 it was the last of March before many bugs appeared. For the season's work the first definite observations and notes were made April 4, 1908, at West Raleigh, where all the work herewith recorded was done. The season was a little late, but bugs were then present in considerable numbers, although no eggs were discovered until a few days later, and the first young were found on April 14; hence this date is considered as approximately the beginning of the first seasonal generation. Some springs may bring forth adults at an earlier date.

Feeding and Mating.—Mating does not ordinarily take place until the bugs have fed from a week to ten days, but the first egg mass may be deposited the next day after mating. The females under observation in the laboratory mated usually the day before each egg mass was laid, but those confined without males laid just as regularly and in the normal manner. Mating occurs during the day, the pairs often remaining together several hours.

Egg-laying Habits.—It is generally supposed that twelve is the normal number of eggs deposited in each mass, being placed on end in two parallel rows of six each, closely cemented together, the eggs usually alternating like the cells of a honeycomb. As a matter of fact, the eggs are always placed on end, but a greater number are laid in more or less irregular masses than in two parallel rows of six each. Out of ninety-four egg masses laid in the laboratory by females under observation, sixty-two were irregular in form, but con-

tained twelve eggs each, while only nineteen were regular with twelve eggs each, and thirteen masses varied in numbers from eight to fourteen. Twelve eggs for each mass is undoubtedly the average number, as evidenced by the fact that three females laid eleven once and thirteen in the following mass, while another laid ten and then fourteen eggs. In all instances observed where less than eleven were laid at one time, or where eleven eggs were deposited two or three times in succession, the female died shortly afterward.

The table—giving the egg-laying record—shows how often the egg masses are deposited, and it will be noticed that this time varies from two to fifteen days, but on an average of one mass about every four days.

Concerning the time consumed by a female in depositing the eggs, a marked regularity exists. I have watched several egg masses deposited and find it takes about thirty minutes to deposit twelve eggs. A quotation from notes made at the time will serve as an illustration:

"April 15, 1908, 4 P. M.—I have just watched and timed female of Pair No. 13, deposit a mass of twelve eggs. At 2:50 P. M. she was observed in the position assumed when about to commence deposition. She was apparently straining the abdominal muscles, and moved the abdomen up and down occasionally, during which process she frequently stroked the tip of her abdomen with either hind leg. During this process a drop of moisture appeared probably to serve as a glue for the first egg. At 2:56 P. M. the first egg was dropped, and the remaining number, making a regular mass of twelve in all, were deposited from 2:56 until 3:25, when the last egg appeared, or exactly twenty-nine minutes after dropping the first egg. Counting the six minutes that she remained in position preparatory to laying the first egg, it required thirty-five minutes for the whole process. The time elapsing between the appearance of each egg is almost exactly two and one-half minutes."

Incubation of Eggs.—The incubation period varies greatly with the temperature. Eggs deposited from April 9 to 15 required an average of eleven days, some requiring twelve days, while from May 12 to 21 the average was about six days. In hot summer weather they may hatch on the fourth day.

EGG-LAYING RECORD OF HIBERNATED INDIVIDUALS.

As already stated, these observations were commenced on April 4, when a very few eggs may have been present in the fields; hence of the fourteen pairs selected for the egg-laying record some may have deposited one mass. For this record, pairs were taken and confined in large glass vials with suitable food and a strip of blotting paper to absorb surplus moisture. It is my opinion that too little absorbent was used, the lack of which caused the premature death of some individuals. Six pairs were taken on April 4, and eight pairs on April 7. They were given fresh food (collard or cabbage) daily and the number of eggs were counted and removed each morning. As the eggs are laid during the daytime, the record is always one day behind as regards the actual date when the eggs were laid.

The shape of the egg mass, whether regular or irregular, and number of eggs, are represented in vertical volume in table, the letter "R" meaning regular, that is, two uniform parallel rows ("12-R" meaning twelve eggs in two rows of six each) and "I" meaning irregular ("12-I" meaning twelve eggs in an irregular mass).

EGG-LAYING RECORD OF *MURGANTIA HISTRIONICA*. HAHN.

Date.	Daily Record of Fourteen Females of the Hibernated Generation.													
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
1908.														
April 4														
5														
6														
7	12-I	12-R	12-R		12-I									
8				12-I		12-I								
9			12-I			12-I		12-R	12-I	12-I				
10	12-R	12-I			12-I									12-I
11			12-I				12-I			12-I		12-R	12-R	
12				11-I							12-I			
13	12-R							12-R	12-I					
14		12-I	12-I		12-I	11-R				12-I				12-I
15														
16				13-R			12-I		12-I		12-I	12-I	12-R	12-I
17										12-I				
18														
19			12-I					12-I						
20	12-I	12-I			12-I	11-R						12-I		
21				12-R			12-I		12-I		12-R			12-I
22	12-I							12-R						
23			12-I		12-I				12-I			12-I		Died
24													12-I	
25		12-I				12-R				12-I	12-R	Died		
26				12-I					12-I				Died	
27	12-I		12-I		12-I	11-R	10-R	11-I						
28		5	Died							4				
29		3						13-I		Died	Died			
30								Died	12-R					
May 1	12-I			8-R										
2				Died	12-I									
3						Died								
4														
5		2												
6														
7		Died					14-I							
8														
9														
10									12-I					

EGG-LAYING RECORD OF MURGANTIA HISTRIONICA. HAHN.—*Continued.*

Date.	Daily Record of Fourteen Females of the Hibernated Generation.													
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
1908.														
May 11														
12	12-I				12-R									
13														
14									11-R					
15	11-R													
16					12-I				Died					
17														
18							12-R							
19	12-I				12-I									
20							12-I							
21														
22	12-I													
23					12-I									
24														
25	Died						12-I							
26														
27							12-I							
28					12-I									
29							12-R							
30														
31					12-I									
June 1														
2														
3							Died							
4					11-I									
5														
6														
7														
8														
9					12-I									
10														
11					Died									
Total Egg Masses	11	8	7	6	15	6	10	6	9	6	4	4	3	4
Total Eggs	131	70	84	68	179	69	120	72	107	64	48	48	36	48

From the above record, we determine that the length of life of individuals varied from twenty-two to sixty-nine days in confinement; also that the number of eggs deposited varied in about the same proportion. As a matter of fact, it is probable that those females dying before depositing at least six egg masses would have lived longer under more favorable conditions. At the same time Nos. 2, 4, 8 and 10, females that deposited eggs quite irregularly toward the last, in all probability died of natural causes; hence it would seem that by counting the average of the number of eggs obtained from females depositing at least six egg masses, we would have a fair average number that might be laid under normal or natural conditions. Granting this to be a correct supposition, we have ninety-nine as the average number of eggs laid by each hibernating female.

EGG LAYING OF SECOND GENERATION.

To serve as a check on the egg-laying record of the hibernated generation and to determine which, if either, lays the greatest number of eggs during their lifetime, an attempt was made to get a similar record for individuals of the second seasonal generation. For this experiment nymphs in the last stage of development were collected from the field, taken to the laboratory, reared to adults and from them, on August 10, fourteen pairs were selected and isolated in 4-ounce bottles with suitable food. Unfortunately, the mortality among these specimens was quite high, due, I am now convinced, to an excess of moisture accumulating in the bottles. Consequently the record is not as satisfactory as might be wished for, but at the same time is rather interesting.

EGG RECORD OF FOURTEEN FEMALES IN SECOND GENERATION.

Out of this number separated on August 10, seven died between August 24 and 27, after laying from twelve to thirty-six eggs each. Three more died on August 31, September 4, and September 7, respectively, each one having laid thirty-six eggs. On September 21 another female died, at forty-four days of age from maturity, after laying four egg masses containing forty-six eggs in all.

There remained only three females out of the original fourteen, and as they laid a larger number of eggs and lived so much longer, their individual record seems to be of particular interest, and is as follows:

The female of Pair No. 8 became adult on August 7 or 8, lived until October 5, or fifty-eight days, and deposited seventy-two eggs, or a mass of twelve eggs each, on the following dates: August 20 and 24, September 8, 17, 21, and 26.

The female of Pair No. 9 became adult August 8, lived until October 10, or sixty-three days, and deposited seventy-one eggs, or a mass of twelve eggs each (except once, when only eleven eggs were found), on the following dates: August 20 and 29, September 2, 10 (eleven eggs), 17 and 21.

The female of Pair No. 10 became adult August 7 or 8, lived under observation until October 10, when she escaped, after depositing eighty-four eggs or seven masses of twelve eggs each, on the following dates: August 20 and 29, September 7, 11, 20, 25, and 29.

As already stated, it seems probable that the females that died so soon after maturity were killed by excessive moisture in the bottles. In other words,

the moisture caused them to get fastened to the sides of the bottles, where they died in their struggle to loose themselves. As this experiment was followed closely, I feel confident in concluding that the average number of eggs deposited by the second brood is six or seven masses of twelve eggs each, or from seventy-two to eighty-four eggs. This is less than the average for the hibernating brood.

LENGTH OF LIFE CYCLE.

There is some variation in the duration of the young stages, particularly the 4th and 5th instars. Chittenden records the life cycle for bugs hatching in March, as seventy days, including the egg stage, which covered eleven days. My record of bugs that hatched on August 24 and 25 shows the life cycle, exclusive of the egg stage, covered from fifty-seven to sixty-five days.

The following table shows the record of four individuals which were kept in the unheated laboratory.

LIFE CYCLE OF FOUR INDIVIDUALS.

No.	Hatched.	End of First Instar.	End of Second Instar.	End of Third Instar.	End of Fourth Instar.	End of Fifth Instar. Becoming Adult.	Total No. Days.
1---	Aug. 25	Aug. 30-31 ¹	Sept. 7-8 ¹	Sept. 15	Sept. 27	Oct. 23	59
2---	Aug. 25	Aug. 30-31 ¹	Sept. 7	Sept. 15	Oct. 2	Oct. 29	65
3---	Aug. 24	Aug. 30	Sept. 7-8 ¹	Sept. 16-17 ¹	Sept. 26	Oct. 20	57
4---	Aug. 24	Aug. 30	Sept. 7-8 ¹	Sept. 16-17 ¹	Sept. 30	Oct. 27	64

As evidence that the duration of the fourth and fifth instars may vary, it is only necessary to study the above table, and as further proof compare these dates with the time recorded by Chittenden, as above mentioned. He states: "The first or egg stage covered eleven days. The time from the hatching of the eggs until the first molt gave the first larval instar or nymph period seven days; the second instar required thirteen days; the third, eight days; the fourth, fourteen days; while the fifth or pupal instar covered seventeen days—a total of seventy days or ten weeks."

The life cycle of the first generation was not as long, and probably means that the food supply governs to some extent the rapidity of growth. The recorded dates are given below.

NUMBER OF GENERATIONS ANNUALLY.

Three full generations, and perhaps a partial fourth, are all that are produced in the vicinity of Raleigh. This assertion is based on notes secured by careful observation resulting in a discovery that the bugs maturing after September 1 do not lay eggs the same season, but, on the contrary, live during the fall, and hibernate when cold weather commences. Considering the large number of young bugs usually present in the fields during November, it is not strange that a full fourth and fifth generation has been credited to this species. Indeed, one writer has stated that there may be seven or eight. Having learned, however, that females may live and continue depositing eggs

¹With these the molt occurred some time between 5 P. M. and 8:30 A. M. the following day.

for more than two months, the presence of young bugs the last of November may be accounted for, and safely classed as belated individuals of the third generation.

In the spring of 1908 the earliest individuals of the first brood became mature on May 25, and deposited eggs nine days later. This showed that the first generation took at least fifty-one days, exclusive of the egg stage, to become full grown and commence to deposit eggs. At this rate, allowing four days for eggs to hatch, the first individuals of the second generation became mature fifty-five days later, or on July 29, and this would throw the first adults of the third brood well into September.

It should be understood that many eggs are laid during September, October, and even November, but my observations show that these are laid by females maturing before September 1. As a matter of fact, the generations overlap completely after the last of May, and there may be a difference of over two months in the age of individuals of each generation.

PREVENTIVE AND REMEDIAL MEASURES.

The harlequin cabbage bugs are by no means easy to control, but the possibility of preventing their presence in destructive numbers depends largely on the individual farmer or gardener. While the adults fly readily, they usually confine themselves to one locality as long as there is sufficient food, and for this reason the gardener who makes a vigorous fight against them in his own fields may depend upon it that no serious reinfestation will result from neighboring fields unless they happen to lie very close together.

The recommendations that follow are based upon the known habits of this pest with a view of taking advantage of their weakest points.

Winter Treatment.—Knowing that the adults hibernate during winter, the practice of clean farming suggests itself as a valuable preventive measure. It is a well-known fact that this pest is reduced to small numbers on large cultivated areas that are properly cleared of remnants of old crops, followed by fall, winter or early spring plowing. A good illustration has come under the writer's observation in the case of the farm of the Central Hospital, located at Raleigh. This farm embraces several hundred acres of cultivated land, of which a good many each year are devoted to the growth of cabbage, collards, and turnips, and which furnish extensive feeding ground for the harlequin bug. The manager advises me that he formally attempted to save seed from these crops, and while doing so the insects were very hard to control, but that he has now abandoned this, and consequently is enabled to get his fields cleaned up early in the fall. The result is that the bugs are not troublesome, owing to the small numbers that survive the winter. Similar results have been obtained on the farm of the Agricultural College. Farmers who allow a quarter or half acre of worthless plants to remain during the late fall months as food for harlequin bugs are simply inviting trouble.

Early Spring Destruction.—As a preventive measure, the destruction of the bugs that first appear in spring should be given first importance. We could not consistently urge this practice if the bugs commenced egg laying when they first appeared, but we know that about two weeks' time is devoted to feeding and to mating before eggs are deposited. As a general rule, the bugs

appearing earliest congregate on a few plants, flowering mustard, turnips, or collards furnishing favorite feeding grounds. From such places they should be collected by hand, or killed with pure kerosene in case the plants are worthless. The true value of this practice is illustrated by considering the following:

Rate of Increase.—As an illustration of the benefit derived from destroying the bugs before they have commenced to lay eggs, we see by referring to the egg-laying record, that each female deposits an average of about one hundred eggs. There are three full generations annually. Suppose we kill a single female and thus prevent one hundred young of the first generation, of which one-half might be females. If these fifty reproduced at the same rate the second generation would number 5,000, and counting only one-half of these as females, each capable of producing one hundred young, the third generation would reach the enormous number of 250,000, the progeny of one female in a single year. We can divide this number by 100 and still have 2,500 as the number of bugs prevented by killing one individual when she first appears in spring.

During the warm summer months a large per cent of the eggs are destroyed by a minute parasite in the form of a tiny black fly; but as a general rule, they do not become abundant until the first generation is well developed, so that the destruction of the bugs that produce that generation will result in greater benefit than similar work later in the year.

Hand Picking.—During the summer months harlequin bugs are liable to occur in small numbers, even where the previous recommendations have been followed, and to prevent their increase, collecting by hand is the most profitable remedy. Progressive truckers employ children for this work and find it pays better than to let the bugs increase until spraying becomes necessary.

Spraying.—Kerosene emulsion of 15 per cent strength may be used to kill small or half-grown bugs, and is also somewhat effective against the mature forms. However, when the bugs are sufficiently numerous to make spraying profitable, much injury has usually been done, and this situation should be avoided by the methods already suggested.

When kerosene emulsion is employed it should be applied with a good spray pump, forcing the spray under high pressure, knocking the bugs to the ground and covering them where they lie. Some adult bugs will always survive, necessitating a second or third treatment.

Harlequin bugs feed entirely by sucking, and arsenical poison sprays are therefore useless. Kerosene emulsion kills by contact, so unless the individual bugs are hit by the spray, they will not be killed.

Fall Destruction.—Toward the end of every season, harlequin bugs frequently become numerous on remnants of crops that are of little or no value and usually no attempt is made to destroy them. From what has already been stated, it is evident that they are the ones that will pass the winter. Here, then, is an opportunity to destroy large numbers that would otherwise have to be collected the following spring; in this case the suggestion is again based on the life-history of the insect, that is, the fact that those maturing after about September 1 do not lay eggs the same fall. During October and November, there is ample time to destroy the bugs to protect the following year's crop.

In the opinion of the writer, time put in this fall destruction will prove to be well spent and should be considered as an essential part of the fight against this pest.

This work may be accomplished by hand collecting, spraying or cleaning off remnants of crops, followed immediately by deep plowing. Every adult killed in the fall may mean one less the following spring, and the aim should be to prevent their going into hibernating quarters.

IS NEOCOSMOSPORA VASINFECTA (Atk.) SMITH, THE PERITHECIAL STAGE OF THE FUSARIUM WHICH CAUSES COWPEA WILT?

By B. B. HIGGINS.¹

One of the first wilt diseases to be attributed to the *Fusarium* type of fungi was a disease of cotton described by Atkinson² in 1892. The wilting of the cotton was attributed to the plugging of the vessels of the plant near the base of the stem by the mycelium of a fungus. This fungus was isolated and described by Atkinson² as a new species of *Fusarium* under the name *Fusarium vasinfectum*.

Atkinson also found a *Fusarium* on the surface of some of the sick plants, but considered this a saprophyte distinct from the internal fungus.

A few years later (1894-1899) Erwin F. Smith made a much more extensive study of the wilt-producing *Fusaria* on cotton, also on watermelon and cowpea.³ He found an internal fungus plugging the vessels of the stems, and producing in them (melon and cowpea) short hyaline, nonseptate (or occasionally, once or twice, septate) spores, microconidia. The *Fusarium* was found in all three host plants, cotton, watermelon, and cowpea, and was considered by Smith to be specifically identical with *Fusarium vasinfectum* Atk.

After the plants infected with internal fungus had died, another spore form, "macroconidia," appeared on the surface of the stems. This form is described by Smith¹ as consisting of lunulate, 3 to 5 septate spores, 30 to 50 by 4 to 6 μ ., which are borne on the surfaces of dead stems in immense numbers or on innumerable, small, oval, or hemispherical conidia beds which arise from the internal mycelium and consist of compact, irregularly branched, short conidiophores. The spores, when germinated in water or in acid or alkaline agar or in very moist air, are said to produce conidia indistinguishable from those borne by the internal fungus.

The enlarged cells in the hyphæ of the fungus described by Atkinson as resembling gemmæ were also noted by Smith on stems of watermelon, and cultures of the fungus from melon and cotton and were regarded as clamydospores.

Smith also found red perithecia growing on the roots and stems of cotton, watermelon, and cowpea.

All four of these fungous forms were considered by Smith to be stages in the life-history of one fungus, which he named from its ascogenous stage *Neocosmospora vasinfecta*.

¹[The investigation upon which this article is based was begun by Mr. Higgins, at the suggestion of Dr. Stevens, to form material for a Master's thesis. The preliminary studies revealed a problem of unexpected significance and led to modification of the original plan and to the devotion of a portion of Mr. Higgins' time as laboratory assistant of the Experiment Station to the completion of the investigation. The research was thereafter carried on under the direction of Dr. Stevens, partly as Station work and partly in pursuance of college study.—DIRECTOR.]

²Some Diseases of Cotton. Ala. Sta. Bul. 41, pp. 19-29.

³Wilt Disease of Cotton, Watermelon, and Cowpea. Bul. No. 17, U. S. Dept. of Agr., Div. of Veg. Phys. and Path.

Smith's conclusion as to the genetic relationship of these fungous forms has been generally accepted, although only a very few writers have reported actually finding the perithecia,^{2,17} and no one, so far as I can find, has by means of pure cultures corroborated Smith's conclusions.

Whether Smith did or did not succeed in producing perithecia from the internal fungus taken from the stems of the cowpea, is not quite clear. In Bulletin 17 (Div. of Veg. Phys. and Path., U. S. Dept. of Agr., p. 11) he says: "No perithecia ever developed in any of the cultures made from internal or external conidia taken from the cotton or watermelon."

Thus, although denying perithecial production by conidia taken from watermelon and cotton, he does not deny perithecia production by conidia from the cowpea fungus. From this, one might be led to infer that perithecia were obtained from conidia taken from the cowpea. The only positive statement of the production of perithecia from conidia is made on page 10 of the above-mentioned bulletin, where he says: "Perithecia have also been produced from 150 or more microconidia. They were isolated by the poured plate method, the material being derived from an agar culture about two weeks old which was made from ascospores." No statement is made as to whether the culture producing these ascospores was obtained originally from the internal fungus or from the outer perithecial fungus.

With these facts in mind, the present work was begun in the fall of 1908 in the laboratory of the Station, to learn so far as possible the exact conditions under which perithecia are produced, and if possible to obtain perithecia from pure cultures of the internal fungus from cowpea stems.

There has long been much question as to why certain imperfect fungi, *e. g.*, *Colletotrichum gossypii*, *Glucosporium fructigenum*, etc., produce perithecia abundantly under almost any conditions, while other strains of what is apparently the same fungus do not produce perithecia at all. Again, the perithecia-producing power seems to come and go in the same strain. It was hoped by the study of selected pedigree cultures to throw light upon this point regarding the forms under discussion.

¹Smith *loc.*

²Butler, E. J., Fungous Diseases of India in 1903. Ztschr. Pflanzenkrankh. 15 (1905), pp. 44-48.

³Delacroix, G., Cotton Disease in Egypt. Agr. Prat. Pays Chauds, 2 (1902), No. 8, pp. 135-143; Jour. Agr. Trop. (1902), No. 14, pp. 231-233.

⁴Delacroix, La Maladie des osillets d'Autibes. 1901.

⁵Delacroix and Maublanc, Encyclopedie Agricole Maladies Parasitaires des Plantes Cultivées (*Neocosmospora vasinfecta*), pp. 333-334.

⁶Duggar, B. M., Fungous Diseases of Plants, pp. 233-239.

⁷Evans, G., Cotton Wilt in Central Provinces. Agr. Jour. of India, 3 (1908), I, pp. 78-80.

⁸Fletcher, F., Notes on Two Diseases of Cotton. Jour. Khediv. Agr. Soc. and School Agr., 4 (1902), 6, p. 42.

⁹Jaczewski, A. von, On the Occurrence of the Wilt of Sesame. Ann. Mycol., I (1903), I, pp. 31-32; abs. in Bot. Centbl. 92 (1903), 23, p. 543.

¹⁰Lewis, A. C., Black Root Diseases of Cotton in Georgia, and Its Control. Ga. Bd. Ent., Bul. 28.

¹¹Malkoff, K. A., Plant Diseases and Other Injuries to Cultivated Plants. Ghod. Otchet. Drzhav. Zeml. Obitna Stanz. Sadovo. (Jahresber. Staatl. Landw. Vers. Stat. Sadovo) 4 (1906).

¹²Orton, W. A., Some Diseases of the Cowpea. Bul. 17, Bur. of Plant Industry, U. S. Dept. of Agr., pp. 9-23.

¹³Orton, W. A., A Study of Disease Resistance in Watermelons. Abs. in Science, n. ser. 25 (1907), 634, p. 288.

¹⁴Orton, W. A., Cotton Wilt. U. S. Dept. of Agr., Farmers' Bul. 333, pp. 5-54.

¹⁵Reed, H. S., Parasitism of *Neocosmospora vasinfecta* Science, n. ser. 23 (1906), 593, pp. 751-752.

¹⁶Smith, R. I., and Lewis, A. C., Black Root Disease of Cotton. Ga. Bd. Ent., Bul. 22, pp. 237-275.

¹⁷Sorauer, P. Handbuch der Pflanzenkrankheiten, Dritte Auflage, p. 204.

Abundant material was found in the fields of the College and Station farms. Externally, the diseased cowpea plants presented the characteristic wilted appearance as fully described by Orton.¹ Internally, the woody portion of the stem near the ground was browned and the characteristic conidia-bearing mycelium was found in the vessels.

After the plants had died, innumerable small, roundish, salmon-colored spore clusters appeared on the surface of the stems. These tufts were made up of large sickle-shaped, 3-5 septate spores, borne on the ends of short, irregularly branched hyphae (Figs. 2 and 3).

For convenience in distinguishing the different fungous forms found in or on the cowpea stems, the fungus found in the ducts of the plants will hereafter be designated the "internal Fusarium"; the spore clusters found on the surface of dead stems will be called the "external Fusarium"; and the ascigerous form will be mentioned as such.

The work for the first month was confined almost entirely to searching for red perithecia, described by Smith.¹ The stems and roots of hundreds of sick or dead plants from various fields were examined. A great many stems and roots were also brought to the laboratory and placed in tubes with the hope that perithecia would develop upon them; yet, all these early searches for perithecia were unsuccessful.

On October 31, 1908, pure cultures of the internal Fusarium were obtained by aseptic transference of the mycelium from inside the stems to plates of cowpea-leaf agar.

From these original cultures very numerous transfers were made to study the effect of different media upon the fungus. The fungus (internal Fusarium) was grown on cowpea agar, cowpea-leaf agar, carnation agar, Irish potato, rice, and stems of green cowpeas.

Of the last-named medium more than two hundred tubes were prepared and inoculated, as follows:

Stems of almost mature cowpea vines were cut in pieces 10-12 cm. long and placed in test tubes containing about 3 cc. of water. They were then autoclaved at 120° C. for twenty minutes. All were inoculated with mycelium of the internal fungus.

This medium, it would seem, should give the nearest possible approach of any medium to the natural food and environment of the fungus. The ascigerous stage never appeared, however, although the tubes were kept and examined at intervals for more than four months. Neither did the ascigerous stage appear on any of the other media.

On the same day that the original isolation was made (October 31) pieces from three diseased stems were placed in test tubes and set away in the laboratory.

The perithecia of a great many ascigerous fungi (*Melanospora* being specially abundant) developed on these stems. After about two months a few bright-red perithecia appeared on one of the stems. On examination, they were found to agree in every particular, size, shape, color, and general structure of perithecia, of asci, and of spores, with Smith's² description of the perithecial stage of *Neocosmospora vasinfecta*.

On January 16 one of these perithecia was crushed, placed in a tube of melted pea agar, and poured into a Petri dish. When the ascospores began

¹Orton, lc.

²Smith, lc.

to germinate, one of the germinating spores was lifted out with the aid of a dissecting microscope, and transferred to another plate. In about a week from the time of sowing spores very small colorless perithecia appeared around the center of the colony; the second day after the perithecia were first noticed they began to turn red, and by the end of another week they were of a bright-red color and contained ascospores. Short, hyaline, continuous or once septate conidia (microconidia of Smith)¹ were also produced in abundance. This colony was kept pure, and from it the material for the first transfers in pedigree cultures was obtained. It therefore constitutes generation No. 1 in this experiment. In all, fifty-four colonies were produced from this one perithecium, and every colony produced both perithecia and conidia.

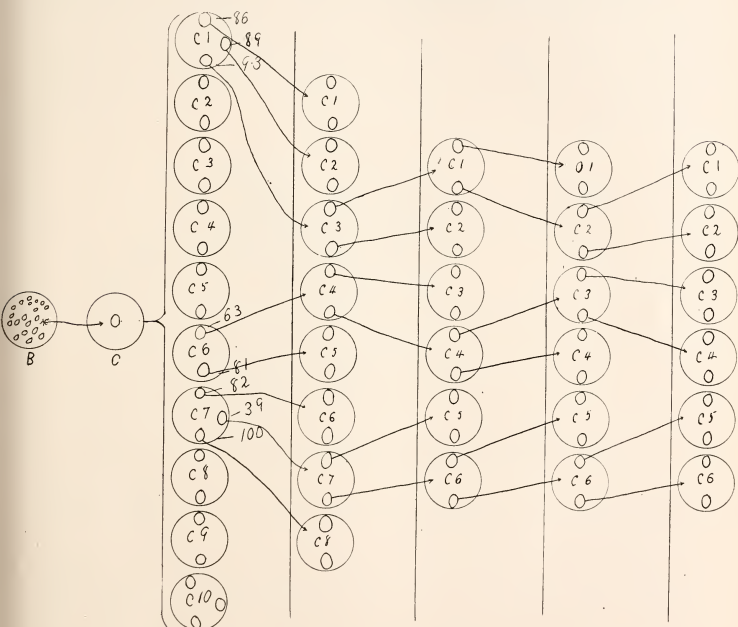


FIG. 1.—Pedigree diagram, showing method of recording the pedigrees of the cultures; *b*, culture from original perithecium; *c*, single colony from *b*, generation No. 1. Numbers within the circle are the numbers of the plates.

Pedigree Cultures.—By pedigree cultures is meant, cultures in which the parentage (whether ascosporic, conidial, or mycelial) of any colony can readily be traced back to the perithecium taken from the cowpea stem. Concerning these pedigree cultures, records were kept of all marked variations in every colony. The parentage records were kept by means of diagrams, which were meant so far as possible to show graphically the manner in which each transfer was made (Fig. 1).

¹Smith, lc.

It was suggested by Smith that remoteness of origin from the ascospore might interfere with the perithecia production of this fungus. It was also suggested to the writer that by taking advantage of small variations of the fungus in the direction of lessened perithecia production, it might be possible to produce a strain which would not produce perithecia at all.

To test these two points, transfers to new media were made from the original colony (generation No. 1) in three ways:

1. Bits of mycelium bearing no conidia were transferred from the extreme edge of the colony.

2. Conidia were transferred by adding a drop of water to a conidial region, then with platinum loop transferring an oese of this water to new media.

3. Ascosporic transfers were made by crushing perithecia in sterile water on a sterile slide, then after careful examination, under a microscope, to see that no conidia were present, transfers were made with a loop to new media.

Thus, from the single colony of generation No. 1 the following transfers were made: January 30, seven mycelial transfers; February 6, ten conidial (microconidia) transfers; and February 11, fourteen ascosporic transfers. The resulting cultures constitute generation No. 2.

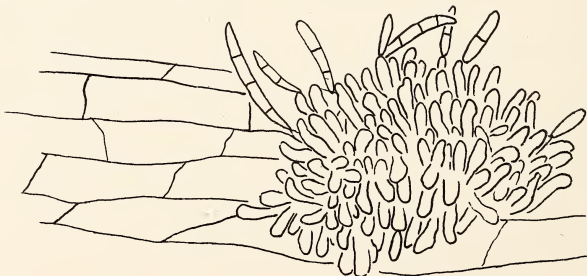


FIG. 2.—Conidia bed from surface of cowpea stem killed by wilt; showing tufts of conidia-bearing hyphae and sickle-shaped conidia, macroconidia.

On February 11, fourteen mycelial and twenty-eight conidial transfers were made from the seven mycelial cultures of generation No. 2. On February 22, sixteen mycelial and sixteen conidial transfers were made from eight of the conidial cultures of generation No. 2.

In these eight colonies there was a slight variation in number of perithecia produced per colony, due possibly to bacterial contamination in some of the plates. Colony No. 1 produced eighty-six perithecia; No. 2, ninety-three; No. 3, eighty-nine; No. 4, sixty-three; No. 5, eighty-one; No. 6, eighty-two; No. 7, thirty-nine, and No. 8 produced one hundred perithecia. No. 4 and No. 7 were both badly contaminated with bacteria. Cultures of both conidial and mycelial origin produced perithecia uniformly and in apparently equal numbers.

Since this time only three straight lines of transfers have been made, that is, mycelial transfers made from mycelial colonies, conidial transfers from conidial colonies, and ascosporic transfers from ascigerous colonies. This has continued in case of the mycelial and conidial lines through six generations, and the ascosporic line has been carried through five generations.

The mycelial and conidial transfers were made about every two weeks, when the plate was nearly covered by the colony. The ascospore transfers were not made until spores were fully mature, emerged naturally and collected in dark-brown masses around the ostecolum, which occurred in about three to four weeks after inoculation.

So far there has been no apparent loss of power to produce perithecia in either the conidial, mycelial, or ascospore lines, nor any marked variation in this respect.

To test the effect of different media on perithecia production, inoculations were made onto plain agar, cba¹, cba+sodium asparaginate+glucose, cba+starch, and cba+glucose. All these media produced perithecia. They were produced most abundantly on cba+sodium asparaginate+glucose and least abundantly on plain agar.

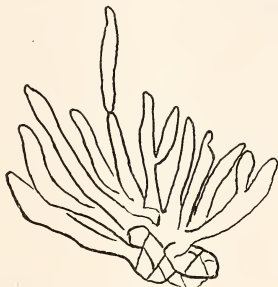


FIG. 3.—Small portion of conidia bed, showing irregular branching of hyphae.

To see if these changes in perithecia-producing power were permanent, cross inoculations were made upon the two media. Two plates of plain agar and two of cba+sodium asparaginate+glucose were inoculated from a colony which had produced nine perithecia per square centimeter on plain agar. A like number of plates was inoculated from a colony which had produced one hundred and seventy perithecia per square centimeter on cba+sodium asparaginate+glucose. Practically the same number of perithecia was produced from each inoculation, six per square centimeter on plain agar and one hundred and sixty-seven per square centimeter on cba+sodium asparaginate+glucose.

These results indicate that the amount of nourishment does not affect permanently the perithecia-producing power of the fungus. It was noticed, further, that the number of perithecia produced varied about proportionately to the amount of mycelial growth. That is, when grown on a medium rich in nutrients (such as cba+sodium asparaginate+glucose) the fungus made a luxuriant growth of mycelium and produced perithecia abundantly, while on media poor in nutrients (such as plain agar) it made a thin, scanty growth of mycelium and produced proportionately few perithecia.

Alkaline Rice.—Tubes of rice were prepared and made alkaline as follows: 8 grams of rice were weighed into each tube, two cubic centimeters of a satu-

¹cba signifies Chemical Base Agar. For details of composition, see article by Stevens and Hall, "Variations of Fungi Due to Environment." Bot. Gaz. 48; pp. 1-30.

rated solution of sodium carbonate added, and autoclaved for twenty minutes at 120° C. These tubes were then inoculated with ascospores. After fifteen days a slight whitish growth could be seen on the surface, and in another week it had covered the surface of the rice. At the end of sixty days a grayish white to dark steel-gray stroma covered the surface of the rice and an abundance of small colorless conidia was found. The stroma, however, showed no perithecia even under careful microscopic examination. At this time (sixtieth day from inoculations) some of the mycelium with conidia was transferred to plates of cowpea-leaf agar. In a few days perithecia appeared in abundance on the new growth. On the ninetieth day transfers were again made from the alkaline rice to agar, with the same results.

The ascigerous fungus was grown on a great many other media, viz., asparagus agar, carnation agar, steamed potato (both Irish and sweet), rice, steamed cowpea stems (both green and cured), and gelatine. Perithecia were produced abundantly on all these media.

EFFECT OF HEAT UPON PRODUCTION OF PERITHECIA.

Twelve agar plates were inoculated; six were placed in an incubator at 27° C. and the other six were left in the open room.

Perithecia appeared on the plates in the incubator in forty-eight hours, while they did not appear on the other plates until the sixth day; but the ultimate number of perithecia produced was practically the same in each case.

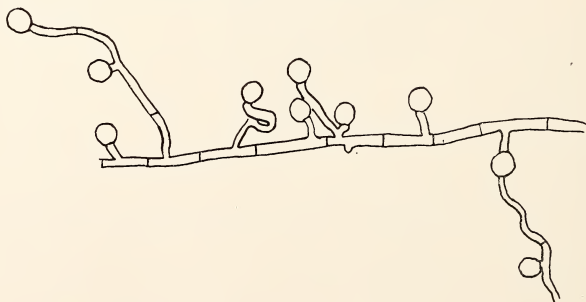


FIG. 4.—Mycelium, bearing several clamydospores from old pea agar culture of internal fungus.

In none of the experiments above recorded was there any evidence of any tendency of a given strain of the fungus to alter its power of ascus production, nor was there evidence that external conditions exert any permanent influence upon this power.

Smith's¹ evidence that the two forms are genetically connected did not seem to the writer to be entirely conclusive. Since Smith's bulletin setting forth his conclusions treats of wilt of cotton, watermelon, and cowpea, it is not always clear what evidence he claims in the case of each separate host. Careful reading shows that all the clear evidence definitely referring to the fungus upon the cowpea that can be found in his bulletin is comprised in the two facts, that

¹Smith, lc.

perithecia of *Neocosmospora* are frequently found on the plants which have been killed by the internal fungus, and that ascospores from these perithecia produced conidia which very much resemble the microconidia of the internal fungus.

As to the first of these facts, such occurrence of perithecia is altogether too rare to have very great weight as evidence that the two fungous forms are genetically connected. Smith¹ reports the wilt disease from eleven localities, while the perithecial stage is only reported from three of these.

Atkinson reports the cotton wilt from seven localities, but does not report any perithecial stage. Since that time wilt disease caused by a *Fusarium* very similar or identical with *Fusarium vasinfectum* Atk. have been studied by many pathologists in diverse sections of the world; but, so far as I can find, no one except Smith and Orton has reported the ascigerous stage of *Neocosmospora* in connection with them. In my own experience, the *Neocosmospora* perithecia have been found on only three plants. In the fall of 1908 stems of a great many diseased plants were put up in test tubes. Only one of these developed perithecia. Of fifty stems and roots put up in this way in 1909 only two developed perithecia of *Neocosmospora*.

The perithecia of several other ascigerous fungi (notably, *Melanospora*) were found much more frequently on these stems than was *Neocosmospora*. Although hundreds of cowpea stems dead or diseased by the *Fusarium* wilt have been examined, I have never found the perithecial stage of *Neocosmospora* in the field.

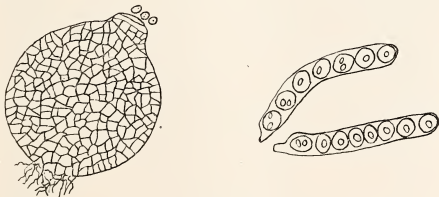


FIG. 5.—Perithecium from artificial culture on cowpea stem (perithecium x 50, asci x 280).

Smith¹ also stated further: "In the interior of these plants, both in the vessels and in parenchyma cells, there was an abundance of mycelium bearing great numbers of small colorless (white) elliptical microconidia, and at the same time, on the outside, on the salmon-colored conidia beds, enormous numbers of big lunulate, 3 to 5-septate macroconidia, the hyphae of the fungus being readily traceable outward from the plugged or partially occupied vessels of the plant to the conidia beds on the surface." This, however, cannot be considered as evidence that the internal fungus is genetically connected with *Neocosmospora*; because *Neocosmospora* does not produce these large lunulate 3 to 5-septate spores such as are found in the external conidia beds.

COMPARATIVE CULTURES.

While making cultures such vast differences were observed between the general appearance of the internal fungus and that of the ascigerous fungus that

¹Smith, *lc.*, p. 33.

it was thought best to make a comparative study of these two fungi to see if the differences were constant and would appear when the two fungi or strains were grown on the same media and under the same environment. The comparative cultures were made on pea agar, gelatine, rice, Irish and sweet potatoes, stems from cured cowpea hay, and stems from green cowpeas.

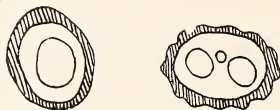


FIG. 6.—Ascospores, from Irish potato; the surface of one roughened, the other smooth (x 1050).

On *Pea Agar* the internal fungus made a profuse white aërial growth and large sickle-shaped 3 to 5-septate conidia, macroconidia, were produced abundantly over the surface of the medium. At the point of inoculation a rather large yellow cluster of these macroconidia was always produced. Small 1-septate or continuous conidia, microconidia, were also found in abundance.

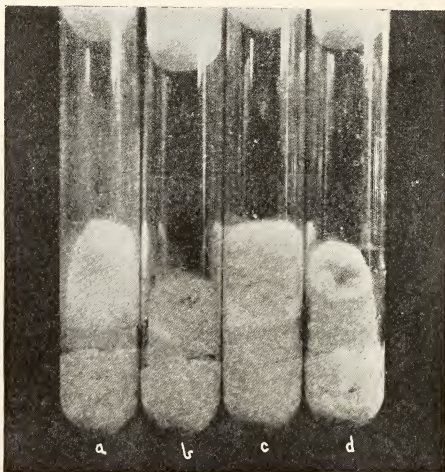


FIG. 7.—Cultures on Irish potato, 8 days after inoculation, showing difference in growth of internal fungus tubes, *a* and *c*, and ascigerous fungus tubes, *b* and *d*.

The ascigerous fungus produced an almost colorless, strict growth. No yellow spore clusters were ever produced and no 3 to 5-septate conidia were ever found. Small, hyaline, continuous or once septate conidia, very similar to the microconidia of the internal fungus, were found in abundance.

On Rice.—Probably the most striking differences shown on any medium were the different colorations produced by the internal fungus and the ascigerous fungus, particularly on rice.



FIG. 8.—Old Irish potato cultures—*b*, internal fungus, showing sclerotia and white floccose growth; *d*, ascigerous fungus, showing numerous perithecia and scant mycelial growth.

Eight tubes of boiled rice were prepared as follows: Eight grams of rice were weighed into each tube and two cc. of water added. The tubes were then autoclaved twenty minutes at 120° C. and inoculated; four with conidia from agar cultures of the internal fungus and four with the ascigerous fungus.

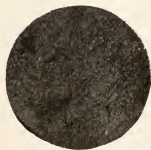


FIG. 9.—Section of sclerotium showing compact mycelial structure (photo micrograph).

The internal fungus again made a much more vigorous, profuse growth. On the fourth day from inoculation a few grains in the top of tubes inoculated with the internal fungus began to turn red. The red color gradually passed down until all the rice in the tube showed some shade of red, from light rose to deep blood-red. As the cultures aged, the coloration gradually deepened until (generally, third or fourth week) it was a bluish purple. As the rice dried out and shrank away from the sides of the tubes a profuse cottony growth of mycelium was generally produced. Macroconidia were produced, but not so abundantly as on agar. Microconidia were very abundant.

In the tubes inoculated with the ascigerous fungus the coloration began as with the internal fungus; except that it was about two days later in appearing, and, instead of turning the rice red, it was changed to a dirty brown color. This did not change further, except possibly to become slightly darker

brown as the rice dried out. Perithecia were produced quite freely, but they were not so red as on potato and most other media. The short uniseptate spores were quite abundant. No sickle-shaped 3-5 septate conidia were found.

On *Gelatine* stab cultures the internal fungus made a rapid growth, entirely covering the surface of the medium in seven days with a profuse, white, aërial growth, which changed to a light pink color at the end of two weeks. Some growth was made throughout the full length of the stab.

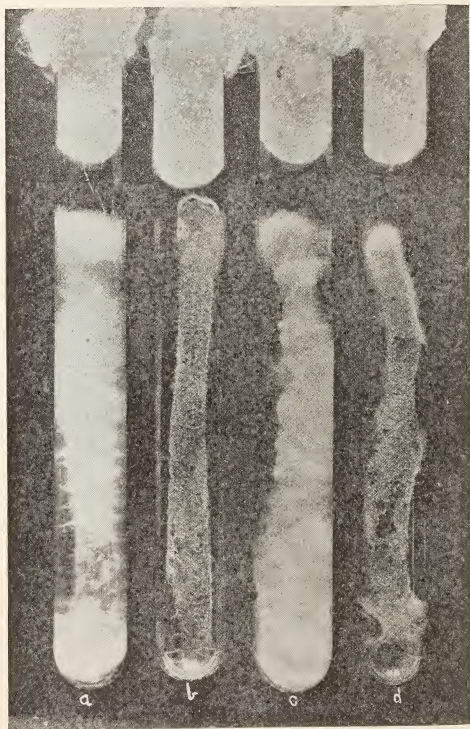


FIG. 10.—Cultures on green cowpea stems showing luxuriant white growth of internal fungus, tubes *a* and *c*, and scanty grayish growth of ascigerous fungus, tubes *b* and *d*.

The ascigerous fungus made a very slow growth. Fourteen days were required for the strict, light brownish mycelial growth to cover the surface of the medium; three weeks to cover it with a mass of blood-red perithecia. No growth was made below the surface of the gelatine.

On Potato.—The internal fungus made a very profuse white aërial growth, while the perithecial fungus made a slow growth of grayish mycelium which was only slightly aërial. This difference of growth is shown in Figs. 7 and 8, which represent two tubes of each fungus six days after inoculation. The mycelium of the internal fungus began to turn pink after it had grown seven days, and yellow clusters of spores appeared at points over the surface of the

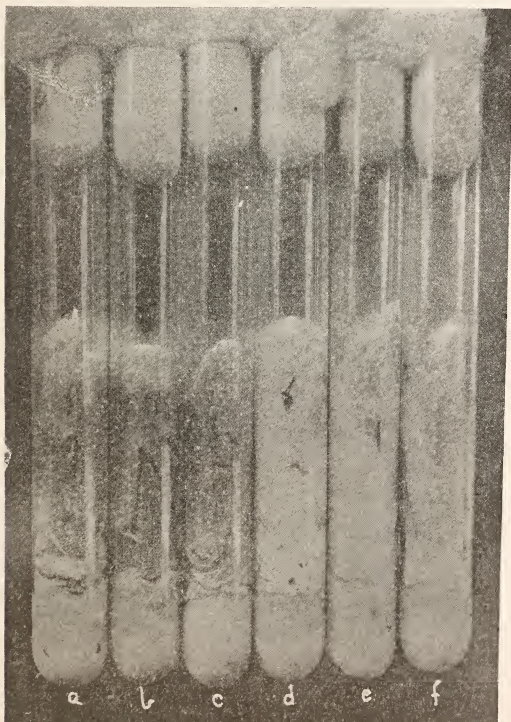


FIG. 11.—Cultures on stems of cured cowpea hay, showing luxuriant white growth of internal fungus, tubes *d*, *e* and *f*, and scanty mycelial growth and abundant perithecia of external fungus, tubes *a*, *b* and *c*.

potato. What appears to be sclerotia (Figs. 8 and 9) were also produced on every potato inoculated with the internal fungus. Four days after inoculation with the ascigerous fungus onto potato a cluster of almost colorless perithecia could be seen at the point of inoculation. This cluster gradually widened and became darker until at end of two weeks the whole surface was covered with a mass of brick-red perithecia. No yellow spore clusters or sclerotial bodies were produced by the ascigerous fungus.

On steamed stems of cowpea hay the growth of both fungi was very similar to that on Irish potato. The internal fungus produced many yellow spore clusters and also many small black sclerotial bodies similar to the bodies produced on the potato, except that those on the pea stems were much smaller. The perithecial fungus again produced a light grayish growth of mycelium and many bright-red perithecia, but no yellow spore clusters and no sclerotia.



FIG. 12.—Portion of compact rhizomorphic strand of the fungus from sweet potato culture of ascigerous stage; *a* is a young perithecium (photomicrograph).

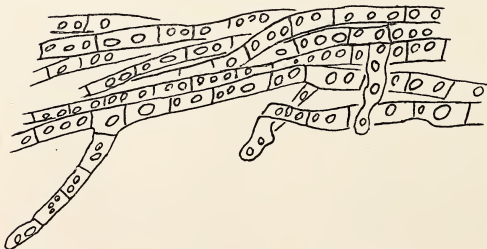


FIG. 13.—Portion of tip of rhizomorphic strand similar to Fig. 12 (x 385).

On autoclaved green cowpea stems the internal fungus rapidly made a very profuse cottony growth of mycelium (Fig. 10), tubes *a* and *c*. Comparatively few conidia of any kind were produced. Both micro- and macro-conidia were found.

The ascigerous fungus made very poor, scanty growth at first. Even two weeks after inoculation scarcely any mycelium could be seen. By the end of the third week, however, the growth of mycelium had become more prominent (Fig. 10, tubes *b* and *d*) and perithecia began to appear abundantly. The mycelium, however, was of a grayish white color and never became so floccose or profuse as that from the internal fungus. No macroconidia were found.

On *Sweet Potato* the growth of the internal fungus was very similar to that on Irish potato.

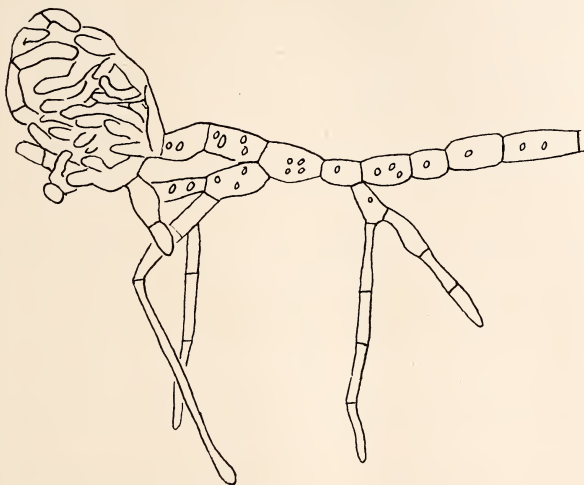
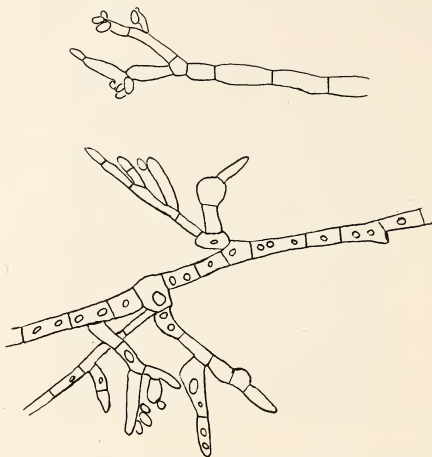


FIG. 14.—Single branch, near tip of rhizomorphic strand, bearing a young perithecia (x 385).

The ascigerous fungus, however, was very different on this medium from its growth on the Irish potato. The mycelium extended out from the surface of the potato in long, compact rhizomorphic strands (Figs. 12 and 13). Perithecia were produced in these strands in abundance, being occasionally produced on single short branches (Fig. 14). Small continuous or 1-septate conidia were also produced in abundance on short fertile hyphæ (Figs. 15 and 16). Considered alone, the habit on this medium would place the conidial stage of *Neocosmospora* in the *Stilbaceae*.

To these points of difference as brought out in my own cultures I may add that Smith failed to secure inoculations when the ascigerous fungus was used, though the parasitism of the internal fungus has never been brought to question. His words are:

"Cowpea inoculations failed with the fungus derived from ascospores of the cowpea fungus. Nine large pots were used, but all of the 170 plants remained free from disease directly attributable to the *Necocosmospora*, although under observation for many months. These were soil inoculations, and an abundance of the fungus was used."



FIGS. 15 AND 16.—Fertile hyphæ from rhizomorphic strand bearing microconidia (x 385).

GENERAL DISCUSSION.

It will be noted that there are several general points of difference between the two fungi under discussion, and that these are maintained in all cultures. The following are the most prominent among these differences:

First. Perithecia are continuously produced in cultures of the ascigerous form, while they were never found in cultures of the internal fungus.

Second. There is a striking difference in the appearance of the mycelial growth of the two fungi. The internal fungus on all media produced a more aërial and more floccose white mycelium than the ascigerous fungus. The growth of the internal fungus on all media was more vigorous and rapid than that of the ascigerous fungus.

Third. Large sickle-shaped 3-5 septate conidia (macroconidia) were present in all cultures of the internal fungus. They have never been found in any cultures of the ascigerous fungus.

Fourth. Chlamydospores are found in all old cultures of the internal fungus. They were never found in any culture of the ascigerous fungus.

Fifth. There seems to be no tendency whatever on the part of the ascigerous fungus to produce bright colors (yellow, red, pink, or purple) in any of the substrata employed. These colors are vivid where the internal fungus is grown on starchy substrata.

These and other differences noted are made more comprehensive to the eye of the reader in the following tabulation:

ASCIGEROUS FUNGUS.

1. Perithecia always present.
2. Growth slow.
3. Mycelium never pure white.
4. Mycelial growth generally scanty.
5. Mycelium usually strict.
6. Macroconidia never found.
7. Clamydospores never found.
8. No bright color (red, yellow, pink, or purple) produced in any substrata.
9. No yellow spore clusters appeared.
10. No growth below surface of gelatine.

INTERNAL FUNGUS.

1. Perithecia never present.
2. Growth rapid.
3. Mycelium on most media pure white.
4. Mycelial growth profuse on rich media.
5. Mycelium aërial, floccose.
6. Macroconidia always found.
7. Clamydospores in all old cultures.
8. Bright colors produced on starchy food (many shades of red and purple in rice, yellow to pink in potato, and pink in gelatine).
9. Yellow spore clusters on agar, potato, and stems of cured cowpea hay.
10. Growth produced below surface of gelatine.

While these differences do not prove conclusively that the internal fungus and the *Neocosmospora* studied are not simply different strains of the same fungus, yet it would seem that these, with the other evidence presented, are sufficient to at least balance any evidence which I have been able to find to the contrary and to reopen this question, which has been regarded as closed.

The evidence for and against this question may be comprehensively summarized as follows:

Indications that the internal fungus and Neocosmospora are genetically connected.

1. Perithecia of *Neocosmospora* are found on stem and roots of plants killed by the internal fungus.
2. When grown in cultures *Neocosmospora* produces conidia very similar to the microconidia of the internal fungus.

Indications that the internal fungus and Neocosmospora are not genetically connected.

1. Perithecia are found very rarely on such plants.
2. Perithecia of many other ascigerous fungi are found on such stems.
3. The perithecial stage of *Neocosmospora* has never been reported in connection with *Fusarium* wilts in other countries.
4. *Neocosmospora* has not been observed to produce macroconidia. The internal *Fusarium* does.
5. The internal fungus produces clamydospores. *Neocosmospora* does not.
6. It has so far been impossible to change one fungous form into the other; *i. e.*, to stop permanently the production of peri-

thecia by *Neocosmospora* or to obtain a perithecia-producing strain from the internal fungus.

7. The two fungi are very dissimilar in general appearance, in manner of growth, and in their reactions on various substrata, as shown in detail above.

SEXUALITY OF PERITHECIA.

In view of the interesting sexual relations shown in the Mucorales¹ it is of interest to note that single hyphæ of *Neocosmospora* can produce perithecia. Therefore, if the perithecia of *Neocosmospora* are the result of any sexual act at all, it must be simply between branches arising from the same hyphæ. That they do not arise from union of the two hyphæ of separate origin is shown in conditions such as that in Fig. 14.

CONCLUSION.

In the light of the above facts, it is unreasonable to conclude that the internal fungus (*Fusarium vasinfectum* Atk.) and *Neocosmospora* are genetically related. For the present and until evidence is found to the contrary, it seems best to regard the *Neocosmospora* as simply an accidental saprophyte, having no relation to the wilt of the cowpea or to the internal fungus, *Fusarium vasinfectum*, which is probably the true cause of the wilt.

¹Blakesley, A. F., Sexual Reproduction in the Mucorineae. Proc. Amer. Acad. Arts and Sci., 40, 4, 1904.

NOTE.—While the present article was in the hands of the printers my attention was called to an abstract in *Annales Mycologici* 8 April, 1910, p. 255-6, of an article by Dr. E. J. Butler, which upon different grounds sustains my own position regarding *Neocosmospora*. Dr. Butler worked with a wilt disease of chick-pea (*Cicer arietinum*). He found the perithecia of *Neocosmospora* on the dead vines, but considered it simply a soil parasite having no connection whatever with the *Fusarium* which caused the wilt. I have not yet seen his original article, so do not know exactly the evidence upon which his conclusion is based. B. B. H.

THE SCUPPERNONG AS A PROFITABLE CROP—METHODS OF GROWING, KEEPING, AND WINE-MAKING—USED AT ITS PLACE OF ORIGIN.

BY W. C. ETHERIDGE.

A large part of North Carolina, particularly the eastern sound-bordering counties, offers an opportunity to the farmers located therein for the development of a substantial industry which may be carried to advantage along with the usual farm operations of the locality, or taken singly and more extensively.

This is the growing for commercial purposes of Scuppernong grapes, to which the section is ideally adapted in soil and climate. With such natural advantages there is wonder that this industry remains undeveloped when the only other factor wanting is a market, the lack of which may be attributed more to an absence of enterprise in seeking than to its nonexistence, for undoubtedly with some effort and advertising a market could be found for the delicious light wine that may be produced from the Scuppernong grape. There are, to be sure, a few large vineyards in the State operated on a commercial basis by several wine companies of another State; but with the small farmer, to whom the Scuppernong might be made to yield as reliable revenue as his staple crops, the industry is dormant.

These grapes are very easily grown, requiring no other care than repairs to the scaffolding or trellis every few years and an occasional pruning; in fact, there is probably no other fruit that will thrive with the minimum of care and attention which is sufficient for the Scuppernong. The writer has in mind a very old vine which has received practically no care for over a hundred years, beyond repairs to the scaffolding, and yet it fruits vigorously.

The vines are always propagated from runners which may be had from any established vine by pulling or digging up the overhanging and rooted branches. These should be set out in the fall, and may be trained either on a scaffold or trellis, the former requiring less attention, while the latter affords easier access for pruning and gathering the fruit and gives the vine more fruit-bearing surface. If a scaffolding is used, the main posts should be of fat pine, if obtainable, as these will last indefinitely, although cypress and juniper make very good ones if the part that is to be buried is given a coating of tar. The running poles are best if of large cypress, or juniper saplings, 3 to 5 inches in diameter, stripped of their bark; yet any sort of pole or rail may be used for this purpose, as it may easily be replaced when rotten. If trellising is preferred, convenience may again be regarded in the selection of posts, as on account of their small size it is not difficult to replace them when needed.

When the vines are trained on a scaffold, pruning presents the only difficulty that occurs in their keeping, and this is obviated by the lack of actual necessity for it. By pulling the dead wood out of the vine once in several years it can be kept in fairly good condition. A trellised vine would, however, require more attentive pruning.

For making wine only ripe and perfectly sound grapes should be used. When fully ripe they are shaken into large sheets of burlap, or cloth, spread underneath the vine, the shaking being easily accomplished by jarring the

vine with a pole crotched at one end by which a hold is obtained on the vine. Such trash from the vine, leaves and broken bits of stems or twigs, as may have fallen into the sheet is carefully picked out and the grapes are ready for the press.

The process is very simple, being only a flat, shallow trough about 8 feet long, $3\frac{1}{2}$ feet wide at one end, tapering down to about 18 inches at the other, and having fixed at about 30 inches from the wider end a wooden roller 6 or 8 inches in diameter. This roller is covered spirally with strips of leather which give it a better catch on the grapes and make it less liable to smash the seed than if its surface were bare. To either or both ends is fitted a crank for turning. When in use, the trough is fixed between four posts at a convenient height for pouring in the grapes and is slightly inclined for the flow of the juice. The grapes are poured into the trough behind the roller, and it is slowly turned over them, crushing out the juice, which is received into a pail or tub placed beneath the lower end of the trough and is then strained into stands usually made by sawing a good oaken barrel through the middle. The juice is afterward filtered through some material that will catch the smaller rags of pulp and broken bits of seed which have escaped the strainer. A filter commonly used in the eastern part of the State is made of small pieces of sea-shells wrapped or mixed with clean, bright broom-grass and placed in a large funnel. This is very effective in clearing the juice.

After filtering, the juice is transferred to barrels, where it may be sweetened at once or after fermentation, this depending upon the quality of wine desired. If the sweetening is done before the juice ferments the wine retains much of the mild, natural flavor of the ripe fruit, but does not have the body, or "tang," that results if fermentation is first allowed. The amount of sugar to be used in sweetening is between two and three pounds per gallon of juice, and varies with the time the wine is to be kept: if it is intended for use within a year or two, less sugar is required than if the wine is to be aged; and less is needed if the sweetening is done before than after fermentation. After the juice is in the barrels the bungs are left out until all the fermentative gases have escaped, and are then driven tightly in.

Converting the fruit into wine is easily the most profitable disposal that can be made of it, provided a market can be found. A bushel of grapes will yield, even with the present crude methods of pressing, three gallons of wine, exclusive of the sugar added in sweetening. This should sell for at least \$2 per gallon, making a gross return of \$6 per bushel for the grapes. The cost of making the wine is small, as the method is a simple and easy one, requiring little skill and no apparatus that may not be provided at home. The only material entering into the process that need call for a direct expenditure is the sugar used in sweetening, and even this is used at a profit, as it increases the volume of the wine in about the same proportion as its own volume, the value of the extra quality of wine produced exceeding the cost of the sugar.

II.—STUDIES IN SOIL BACTERIOLOGY¹—AMMONIFICATION IN SOILS AND IN SOLUTIONS.

By F. L. STEVENS AND W. A. WITHERS, ASSISTED BY J. C. TEMPLE AND W. A. SYME.

In an earlier article² we called attention to the fact that inoculation of soils into solutions gives no adequate criterion of the nitrifying powers of soils, owing to the fact that some nitrifying soils fail entirely to nitrify in solutions, and that when in other cases nitrification occurs to some extent in each medium, the amount of nitrification in solutions is not commensurate with the amount of nitrification by the same soils, as soils. The question naturally arises whether a similar condition does not exist regarding the process of ammonification.

Ammonification for the present purpose may be defined as the conversion of organic nitrogen into ammonical nitrogen. It is probably the most important of all the nitrogen transformations, and accurate knowledge of the conditions which favor it is of permanent importance.

The studies of ammonification which have been made—and they are very numerous and important—have been conducted by isolating organisms and studying the chemical transformations induced by such pure cultures in solutions of artificial composition, or by throwing, in various ways, complexes of species in the form of small amounts of soils, or of suspensions derived from soils, into solutions for the purpose of study.

In view of the importance of the subject and in view of the doubts cast upon the validity of results arrived at by present methods of studying ammonification, a series of experiments was undertaken to ascertain whether reliable conclusions regarding the ammonifying power of a soil can be had by study of its effects when inoculated into solutions.

The bacteriological methods used were similar to those described in the earlier paper mentioned above, with exception as to the form of nitrogen used,³ and may be so understood unless special description is given.

CHEMICAL METHODS.

To 400 grams of soil were added 10 cc. of chloroform and water sufficient, with that already present in the soil, to make 1,200 cubic centimeters, and the mixture shaken for one hour. After settling somewhat, the solution was filtered through a Pasteur-Chamberland filter. An aliquot part was taken. Nitrogen in the form of ammonia was liberated by magnesium oxide, caught in a standard acid solution and titrated with a standard alkali solution.

When the amount of ammonia was very small it was nesslerized instead of being titrated.

The amounts are expressed in terms of nitrogen.

¹Published in *Centbl. Bakt. (etc.)*, 2 Abt., 23 (1909), Nos. 21-25, pp. 776-785.

²Stevens and Withers, studies in soil bacteriology—Nitrification in soils and in solutions. (Thirty-first Rpt. N. C. Expt. Sta., pp. 40-63) and *Centbl. Bakt. (etc.)*, 2 Abt., 23 (1909), Nos. 10-13, pp. 355-373.

³Stevens and Withers, *loc. cit.*

EXPERIMENTS.

Experiment 62 was designed to test the relative rapidity of ammonification in soils as compared with solutions. Two hundred and forty milligrams of nitrogen as peptone, asparagin, and cotton-seed meal respectively were on December 12, 1907, placed in 500 cc. Erlenmeyer flasks, 400 cc. of tap water was added to each and the whole autoclaved at 115° for 15 minutes, then inoculated with 1 cc. of soil suspension from experiment 32³ and allowed to stand nine days.

Two hundred and forty milligrams of nitrogen as peptone, asparagin, and cotton-seed meal respectively were also mixed with 400 grams of soil 1866. The mixture was autoclaved as above and inoculated with 10 cc. of soil suspension from experiment 32 in such a way as to be about two-thirds saturated after inoculation, and then allowed to stand twelve days. Analyses at the end of the period gave results indicated in Table I.

TABLE I.—SHOWING A DIFFERENT INTENSITY OF AMMONIFICATION IN SOILS AND IN SOLUTIONS.

Sample Number.	CONDITIONS.					RESULTS.	
	Time of Incubation—Days.	Medium—Kind.	Inoculum.		Form of Initial Nitrogen.	Ammoniacal Nitrogen Recovered.	
			Kind.	Quantity in cc.		Per Cent.	Mgs. per 100 cc. Solution.
1938----	9	Water-----	Soil-----	1	Peptone----	72.5 ⁴	43.5
1939----	9	Water-----	Suspension from Experiment 32	1	Asparagin--	100.0	60.0
1940----	9	Water-----	Suspension from Experiment 32	1	C. S. M. ⁵ ---	36.5	21.9
1955----	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	Peptone----	26.6	106.4
1956----	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	Asparagin--	32.9	135.6
1957----	12	(Sterile soil 1866.)	Suspension from Experiment 32	10	C. S. M.----	23.1	92.4

It is seen here that though the soil culture received ten times as large an inoculum, *i. e.*, ten times as many bacteria, and stood three days longer, the ammonia produced in it from peptone was 36 per cent of that produced in solution, 33 per cent in the case of asparagin, and 65 per cent in the case of cotton-seed meal.

While the experiment does not admit of definite conclusions, because of the lack of parallelism in duration of the experiment and amount of inoculum, it certainly indicates very strongly that there is a great difference in the ammonifying power of this soil under the two conditions, *i. e.*, (1) when inoculated into solution, (2) when inoculated into soil itself.

³Stevens and Withers, *l.c.*

⁴The ammonia originally present was determined and found to be of negligible quantity.

⁵C. S. M. signifies cotton-seed meal.

Experiment 63 was begun on December 7, 1907, precisely as experiment 62, except that the inoculum was greenhouse soil 1866.

The results are shown in Table II.

TABLE II.—SHOWING A DIFFERENT INTENSITY OF AMMONIFICATION IN SOILS AND IN SOLUTIONS.

Sample Number.	CONDITIONS.				RESULTS.	
	Time of Incubation—Days.	Medium—Kind.	Inoculum—Quantity in Grams.	Form of Initial Nitrogen.	Ammoniacal Nitrogen Recovered.	
					Per Cent.	Milligrams per 100 cc. Solution.
1941-----	9	Water-----	1	Peptone-----	79.1 ⁶	47.5
1942-----	9	Water-----	1	Asparagin-----	78.1	46.9
1943-----	9	Water-----	1	Cotton-seed meal	39.8	23.9
1958-----	12	Soil 1866-----	10	Peptone-----	22.4	86.9
1959-----	12	Soil 1866-----	10	Asparagin-----	28.7	114.8
1960-----	12	Soil 1866-----	10	Cotton-seed meal	17.5	70.0

⁶Original ammonia was of negligible amount.

Conditions similar to those found in the previous experiment are noted. Based upon the per cent of ammonia found, peptone and asparagin are ammonified much more vigorously in solutions than in soil cultures; cotton-seed meal likewise, but not with so marked a difference, there being 28 per cent, 36 per cent, 44 per cent, as much ammonia produced in soil as in solution with peptone, asparagin, cotton-seed meal respectively.

Experiment 88. One hundred and twenty milligrams of nitrogen as cotton-seed meal were weighed into 300 cc. Erlenmeyer flasks, 200 cc. of tap water added, and the whole sterilized.

One hundred and twenty milligrams of nitrogen as cotton-seed meal were also mixed with 200 grams of each soil to be tested, flaked, and sterilized.

One hundred grams of the soil to be tested were well shaken with 200 cc. of water and 1 cc. of the suspension was added to each flask of the solution. One cc. of the suspension was also added to 20 cc. of sterile water, mixed, and this diluted suspension was poured into the sterile soils in the flasks and thoroughly mixed. Soils 1667, 1867, 1783, 1784, 1931, and 2069 were tested in this manner, thereby bringing into 200 grams of solution the same number of organisms and the same species of organisms as were mixed with 200 grams of the soil culture. This arrangement also provided that the organisms in soil media were in soils of the same quality as the soils from which these organisms were derived (identically the same soil, except for sterilization). The cultures were incubated seven days and then analyzed.

The results are given in Table III.

TABLE III.—COMPARING OF SIX DIFFERENT SOILS REGARDING AMMONIFICATION IN SOIL AND IN SOLUTION.

Sample Number.	CONDITIONS.		RESULTS.	
	Medium—Kind.	Inoculum— Suspension of Soil.	Ammoniacal Nitrogen Recovered.	
			Per Cent.	Milligrams per 100 cc. Solution.
2152-----	Solution-----	1667	18.27	10.9
2153-----	Soil-----		9.1	18.2
2154-----	Solution-----	1867	34.3	20.6
2155-----	Soil-----		18.9	37.8
2156-----	Solution-----	1783	23.1	13.9
2157-----	Soil-----		14.7	29.4
2158-----	Solution-----	1784	37.1	22.3
2159-----	Soil-----		22.4	44.8
2160-----	Solution-----	1931	24.5	14.7
2161-----	Soil-----		18.9	37.8
2162-----	Solution-----	2069	24.5	14.7
2163-----	Soil-----		30.8	61.6

⁷Original ammonia was of negligible amount.

Here, again, considering the per cent of ammonia produced, there is a great difference in the intensity of ammonification in soils and in solutions. In five of the six samples of soil tested, ammonification was again greater in the solution than in the soil cultures, while in one instance ammonification was greater in the soil culture.

Not only is there a difference in rapidity and absolute quantity of ammonification, but the rank of the soils as ammonifiers is different according to whether their ammonifying powers are measured in soils or in solutions.

Compared in Soil Cultures, their Rank as Ammonifiers is:	Soil Number.	Compared in Solution their Rank is:
1-----	2069	3
2-----	1784	1
3-----	1867	2
4-----	1931	3
5-----	1783	5
6-----	1667	6

Experiment 82. To test relative ammonifying powers of various pure cultures in soil and in solution.

The tests above recited were made with soils, composites of bacterial species. It was deemed advisable to ascertain how far the conclusions indicated by these tests hold true when pure cultures of species are employed. To this end fifteen pure cultures of ammonifying organisms were obtained from the most

promising sources by plating from soils, cow manure, horse manure, and from two labeled cultures from the laboratory stock, and all of these pure cultures were inoculated into broth.

On March 16, 1908, 120 milligrams of nitrogen as cotton-seed meal were weighed into each of sixteen 300 cc. Erlenmeyer flasks, and 200 cc. of tap water added. An equal amount of cotton-seed meal was mixed with 200 grams of soil in each of the sixteen flasks of the same size. All were autoclaved for one hour. Both soil and liquid media were inoculated with 1 cc. of broth culture. To inoculate the soil flasks, tubes with 20 cc. of sterile water were first inoculated with 1 cc. of the broth culture and this dilution poured upon the soil and mixed with it. Ammonia was determined at the end of the fourth day. The results are given in Table IV.

TABLE IV.—COMPARING AMMONIFICATION OF PURE CULTURES IN SOIL AND IN SOLUTION.

Sample Number.	CONDITIONS.		RESULTS.			
	Medium—Kind.	Inoculum—Kind.	Ammoniacal Nitrogen Recovered.			
			Per Cent.	Difference in Favor of Soil.	Mgs. per 100 cc. Solution.	Difference in Favor of Soil.
2077 ---- 2078 ----	Sterile soil 1867 - Water -----	Organism 1 ----	12.6 24.0	—11.4	25.2 14.4	10.8
2079 ---- 2080 ----	Sterile soil 1867 - Water -----	Organism 2 ----	7.0 12.1	— 5.1	14.0 7.3	6.7
2081 ---- 2082 ----	Sterile soil 1867 - Water -----	B. subtilis ----	25.2 11.0	14.2	50.4 6.6	43.8
2083 ---- 2084 ----	Sterile soil 1867 - Water -----	Organism 4 ----	1.4 0.0	1.4	2.8 0.0	2.8
2085 ---- 2086 ----	Sterile soil 1867 - Water -----	Organism 5 ----	37.2 19.6	17.6	74.4 11.8	62.6
2087 ---- 2088 ----	Sterile soil 1867 - Water -----	Organism 6 ----	23.8 18.7	5.1	47.6 11.2	36.4
2089 ---- 2090 ----	Sterile soil 1867 - Water -----	B. mycoides ----	2.8 5.8	— 3.0	5.6 3.5	2.1
2091 ---- 2092 ----	Sterile soil 1867 - Water -----	Organism 8 ----	22.4 15.9	6.5	44.8 9.5	35.3
2093 ---- 2094 ----	Sterile soil 1867 - Water -----	Organism 9 ----	18.2 15.6	2.6	36.4 9.4	27.0
2095 ---- 2096 ----	Sterile soil 1867 - Water -----	Organism 10 ----	23.8 28.7	— 4.9	47.6 17.2	30.4
2097 ---- 2098 ----	Sterile soil 1867 - Water -----	Organism 11 ----	34.3 28.5	5.8	68.6 17.1	51.5
2099 ---- 2100 ----	Sterile soil 1867 - Water -----	Organism 12 ----	3.5 3.5	0.0	7.0 2.1	4.9
2101 ---- 2102 ----	Sterile soil 1867 - Water -----	Organism 13 ----	32.9 19.6	13.3	65.8 11.8	54.0
2103 ---- 2104 ----	Sterile soil 1867 - Water -----	Organism 14 ----	21.7 18.9	2.8	43.4 11.3	32.1
2105 ---- 2106 ----	Sterile soil 1867 - Water -----	Organism 15 ----	9.8 3.0	6.8	19.6 1.8	17.8
2107 ---- 2108 ----	Sterile soil 1867 - Water -----	Soil susp. 1867 --	27.3 16.8	10.5	54.6 10.1	44.5

Here, basing on per cent of ammonia, ammonification was greater in soils than in solutions in the large majority of cases. In only four instances was ammonification greater in solution than in soils. Basing upon amount converted per cc. of solution, the ammonification was greater in the soil in every instance. Basing upon per cent converted, the rank in ammonifying power is as follows:

Rank Tested in Soils.	Soil Number.	Rank Tested in Solution.	Source of Organism.
1-----	2085	4	Horse manure.
2-----	2097	2	Horse manure.
3-----	2101	4	Soil.
4-----	2107	8	Cow manure.
5-----	2081	12	Soil.
{ 6-----	2087	7	Cow manure.
{ 6-----	2095	1	Manure.
8-----	2091	9	Soil.
9-----	2103	6	Soil.
10-----	2093	10	Soil.
11-----	2077	3	B.—subtilis culture.
12-----	2105	15	Soil.
13-----	2079	11	B.—mycoides culture.
14-----	2099	14	Horse manure.
15-----	2089	13	Cow manure.
16-----	2083	16	Cow manure.

Five species hold the same rank in soil and solution; two have changed one rank; two, two ranks; four, three ranks; one, five; one, six; and one, seven ranks; some assuming a higher rank in soils, others higher in solutions.

It is seen from the tabulation that not only is the absolute ammonifying power different in the two media, but also that the rank of the organisms as ammonifiers is greatly altered by the mode of test.¹

Experiment 105. On May 25, 1908, to further test the same point, whether tests made in solutions are fair criteria by which to judge either the absolute or relative ammonifying power of soils, experiments 105, 200, and 201 were made. In these experiments 120 milligrams nitrogen as cotton-seed meal was used, with 200 grams medium and 1 cc. inoculum.

In these experiments the cultures were all made in duplicate and with checks. Four soils were used, and with each the ammonifying power was tested in three ways, as follows:

1. By inoculation of a suspension into a sterile mixture of cotton-seed meal and water (*i. e.*, solution condition).

2. By inoculation of a suspension into sterile soils.

3. By adding the nitrogenous material directly to the live soil.

The results are given in Table V and summarized in Table VI.

¹While the analyses of all samples were not completed on the same day, the analyses of all cultures inoculated with the same soil were made at the same time. Therefore, while the actual rank of these cultures as ammonifiers is not given here, the general conclusion drawn is legitimate.

TABLE V.—SHOWING AMMONIFICATION IN SOILS AND IN SOLUTIONS.

Sample Number.	CONDITIONS.			RESULTS.			
	Time of Incubation—Days.	Medium—Kind.	Inoculum—Kind.	Ammoniacal Nitrogen Recovered.			
				Per Cent.	Net.	Mgs. per 100 cc. Solution.	Net.
2285----	10	Water-----	Suspension of 1784--	29.00		17.4	
2286----	10	Water-----	Suspension of 1784--	29.40	26.86	17.6	16.1
Average-----				29.20		17.5	
2287----	10	Water-----	-----	2.34		1.4	
2288----	10	Sterile soil-----	Suspension of 1784--	21.01		84.0	
2289----	10	Sterile soil-----	Suspension of 1784--	22.40	19.21	89.6	76.8
Average-----				21.31		85.2	
2290----	10	Sterile soil-----	-----	2.10		8.4	
2291----	10	Live soil 1784--	-----	22.40		89.6	
2292----	10	Live soil 1784--	-----	23.10	21.35	92.4	85.4
Average-----				22.75		91.0	
2293----	10	Sterile soil 1784--	-----	1.40		5.6	
2294----	10	Water-----	Suspension of 1667--	26.20		15.7	
2295----	10	Water-----	Suspension of 1667--	27.10	24.31	16.3	14.6
Average-----				26.65		16.0	
2287----	10	Water-----	-----	2.34		1.4	
2296----	10	Sterile soil 1784--	Suspension of 1667--	9.80		39.2	
2297----	10	Sterile soil 1784--	Suspension of 1667--	12.60	11.20	50.4	44.8
Average-----				11.20		44.8	
2298----	10	Sterile soil 1784--	-----	0.00		0.0	
2299----	10	Live soil 1667--	-----	0.70		2.8	
2300----	10	Live soil 1667--	-----	17.50	9.10	70.0	36.4
Average-----				9.10		36.4	
2301----	10	Sterile soil 1667--	-----	0.00		0.0	
2372----	4	C. S. M. + H ₂ O -	Suspension 2069--	11.20			
2373----	4	C. S. M. + H ₂ O -	Suspension 2069--	9.10	8.98	6.1	5.4
Average-----				10.15		0.7	
2374----	4	C. S. M. + H ₂ O -	-----	1.17			
2375----	4	Sterile 1867--	Suspension 2069--	23.81			
2376----	4	Sterile 1867--	Suspension 2069--	23.11	18.56	46.9	37.1
Average-----				23.46		9.8	
2377----	4	Sterile 1867--	-----	4.90			
2378----	7	Live 2069--	-----	32.21			
2379----	7	Live 2069--	-----	30.11	27.66	72.0	63.9
Average-----				31.16		8.1	
2380----	7	Sterile 2069--	-----	3.50			
2390----	7	C. S. M. + H ₂ O -	Suspension 2069--	14.24			
2391----	7	C. S. M. + H ₂ O -	Suspension 2069--	23.57	18.21	11.3	10.9
Average-----				18.91		0.4	
2392----	7	C. S. M. + H ₂ O -	-----	0.70			
2393----	7	Sterile 1867--	Suspension 2069--	28.01			
2394----	7	Sterile 1867--	Suspension 2069--	24.51	23.46	52.5	46.9
Average-----				26.26		5.6	
2395----	7	Sterile 1867--	-----	2.80			
2396----	7	Live 2069--	-----	32.91			
2397----	7	Live 2069--	-----	37.81	31.86	81.7	73.6
Average-----				35.36		8.1	
2380----	4	Sterile 2069--	-----	3.50			
2363----	4	C. S. M. + water	Soil suspension 1931--	6.77			
2364----	4	C. S. M. + water	Soil suspension 1931--	9.10	7.24	4.8	4.3
Average-----				7.94		0.5	
2365----	4	C. S. M. + water	-----	0.70			
2366----	4	Sterile soil 1867--	Soil suspension 1931--	25.21			
2367----	4	Sterile soil 1867--	Soil suspension 1931--	23.81	17.51	45.0	35.0
Average-----				24.51		10.0	
2368----	4	Sterile soil 1867--	-----	7.00			

TABLE V—Continued.

Sample Number.	CONDITIONS.			RESULTS.			
	Time of Incubation—Days.	Medium—Kind.	Inoculum—Kind.	Ammoniacal Nitrogen Recovered.			
				Per Cent.	Net.	Mgs. per 100 cc. Solution.	Net.
2369----	4	Live soil 1931----	-----	24.51	23.46	54.7 4.5	50.2
2370----	4	Live soil 1931----	-----	26.60			
Average----				25.56			
2371----	4	Sterile soil 1931----	-----	2.10			
2381----	7	C. S. M. + water----	Soil suspension 1931----	4.43	8.05	5.3 0.5	4.8
2382----	7	C. S. M. + water----	Soil suspension 1931----	13.07			
Average----				8.75			
2383----	7	C. S. M. + water----	-----	0.70			
2384----	7	Sterile soil 1867----	Soil suspension 1931----	28.70	23.10	57.4 11.2	46.2
2385----	7	Sterile soil 1867----	Soil suspension 1931----	28.70			
Average----				28.70			
2386----	7	Sterile soil 1867----	-----	5.60			
2387----	7	Live soil 1931----	-----	24.50	22.06	50.2 3.0	47.2
2388----	7	Live soil 1931----	-----	22.41			
Average----				23.46			
2389----	7	Sterile soil 1931----	-----	1.40			

TABLE VI.—SUMMARY OF ALL RESULTS GIVEN IN TABLE V.

Medium.	Soil Inoculum.	Days.	Net Nitrogen as Ammonia. Per Cent.	Days.	Net Nitrogen as Ammonia. Per Cent.
C. S. M. and H ₂ O-----	1931	4	7.24	7	8.05
Sterile soil 1867-----	1931	4	17.51	7	23.10
Live 1931-----		4	23.46	7	22.06
C. S. M. and H ₂ O-----	2069	4	8.98	7	18.21
Sterile 1867-----	2069	4	18.56	7	23.46
Live 2069-----		4	27.66		31.86
C. S. M. and H ₂ O-----	1784	10	26.86		
Sterile 1784-----	1784	10	19.21		
Live 1784-----		10	21.35		
C. S. M. and H ₂ O-----	1667	10	24.32		
Sterile 1784-----	1667	10	11.20		
Live 1867-----			9.10		

It is seen here that at the end of four days soils 1931 and 2069 ammonified most vigorously in natural condition, next in sterile soil plus suspension, and least in the watery suspension; Nos. 1784 and 1667 most in watery suspension. It appears, then, that some soils will give a maximum test of ammonifying power in the liquid medium, others in the soil medium; that the test made in the liquid is not a fair criterion of ammonifying power. Though the differences are not so great as is the case with the phenomenon of nitrification,

they are sufficient to change the rank of soils in ammonifying power—as, for example, in the above case where soil 1931 ammonified more than three times as rapidly in soil as in solution, as did also soil 2069; while soil 1784 ammonified a trifle better in solution than in soil. It is apparent that a proper comparison of the actual field ammonifying power of these three soils could not be had by comparing their ammonifying power in solutions. It is to be noted, also, that in the original data from which these conclusions are drawn determinations were made in duplicate with control cultures, and for the most part with excellent agreement between duplicates.

Experiment 209. On August 20, 1908, an experiment similar to the preceding was also made with pure cultures of several laboratory species and of three “wild” forms, Nos. 5, 7, and 11, isolated from various sources.

To inoculate, 1 cc. of a 48-hour old broth culture was added to 20 cc. of sterile water and poured into the soil flask or into the liquid culture, all in strictly parallel manner. The results are presented in Table VII. The initial nitrogen present in the form of cotton-seed meal was 120 milligrams; incubation was for seven days.

As with the composite inoculations of the last experiment, some species are seen to ammonify more vigorously in solution, other species in soils.

Organism No. 5 produced less than 7 per cent as much ammonia in solution as in soil; *B. megatherium*, 32 per cent; *B. mycoides*, 19 per cent. While organism No. 7 produced only 42 per cent as much ammonia in soil as in solution, organism No. 11 gave 46 per cent.

Ranking the organisms according to their ammonifying power in solution, we have No. 7, No. 11, *subtilis*, *megatherium*, *mycoides*, No. 5; in soil, *subtilis*, *megatherium*, No. 11, No. 7, *mycoides*, No. 5.

Thus it is seen that neither the absolute nor the relative ammonifying power of these organisms for soil can be ascertained by testing them in solutions.

SUMMARY AND CONCLUSIONS.

1. Some bacterial soil complexes ammonify faster in solutions.
2. Some bacterial soil complexes ammonify faster in soils.
3. Some pure cultures of organisms ammonify faster in soils, others faster in solutions.
4. The rank of soils, bacterial soil complexes, or of pure cultures is different as measured in soils or in solutions.

The general conclusion stands out clearly, as it did regarding nitrification, that neither for soils nor pure cultures of organisms can the ammonifying power be adequately determined by testing in solutions; that not even the relative ammonifying power of two soils or two organisms can be determined with certainty by the method of testing in solutions. While there is not so great a discrepancy between results by the solution and the soil method with regard to ammonification as obtains regarding nitrification, still the difference is sufficient to necessitate using soil as the medium in which to test ammonifying powers in cases where any degree of accuracy is desired and to check all determinations by soil cultures.

TABLE VII.—TEST OF PURE CULTURES FOR AMMONIFICATION IN SOIL AND IN SOLUTION.

Sample Number.	CONDITIONS.		RESULTS.					
	Medium—Kind.	Amount in cc.	Inoculum—Kind.	Ammoniacal Nitrogen Recovered.				
				Per Cent.	Excess in Favor of Soil.	Excess in Solution.	Milligrams Per cc. Solution.	Excess in Favor of Soil.
				Found. Average.			Found. Average.	
2437-----	Sterile 1867-----	200	B. subtilis-----	16.84			33.7	
2438-----	Water-----	200		15.44	3.91		30.9	7.8
2439-----		60	B. subtilis-----	11.41			22.8	
2440-----		60		13.05			26.1	
2441-----	Sterile 1867-----	200	B. mycoides-----	8.42			16.8	
2442-----	Water-----	200		7.02	6.22		14.0	12.4
2443-----		60	B. mycoides-----	0.52			1.0	
2444-----		60		2.48			5.0	
2445-----	Sterile 1867-----	200	B. megatherium-----	14.38			28.8	
2446-----	Water-----	200		4.04	9.54		28.1	19.0
2447-----		60	B. megatherium-----	4.21			8.4	
2448-----		60		5.14			10.3	
2449-----	Sterile 1867-----	200	Organism No. 5-----	8.03			16.1	
2450-----	Water-----	200		6.49	6.77		13.3	13.5
2451-----		60	Organism No. 5-----	0.37			0.7	
2452-----		60		0.61			1.2	
2453-----	Sterile 1867-----	200	Organism No. 7-----	11.16			22.3	
2454-----	Water-----	200		10.53	14.87		21.1	29.7
2455-----		60	Organism No. 7-----	25.27			51.4	
2456-----		60		26.16				
2457-----	Sterile 1867-----	200	Organism No. 11-----	12.63			25.3	
2458-----	Water-----	200		10.49	13.15		21.0	26.3
2459-----		60	Organism No. 11-----	24.28			48.6	
2460-----		60		25.13			50.3	

III.—STUDIES IN SOIL BACTERIOLOGY—CONCERNING METHODS FOR DETERMINATION OF NITRIFYING AND AMMONIFYING POWERS OF SOILS.¹

BY F. L. STEVENS AND W. A. WITHERS.²

Nitrate nitrogen is generally believed to be the most readily available and most valuable form of nitrogen for plants. If this view be true, even in part, means of measuring the ability of various soils to produce nitrate nitrogen, to nitrify, are desirable, since on the nitrifying power of the soil would depend to some extent, possibly to a large extent, its productivity. To determine nitrifying power; to recognize deficiencies in nitrifying power; to ascertain the cause of such deficiencies when they exist and to find means of correcting them, all require quantitative studies of this factor of soil fertility. To make quantitative determinations of nitrifying power that shall be of broad utility and general value, methods which may be regarded as standard must be devised and their trustworthiness recognized. The biological equilibrium in soils is one of utmost instability, and variations in methods are likely to lead to great discrepancies in results.³ These facts have been constantly forced upon us during the investigations of the past few years and have led us to the consideration of the question of uniform methods in this regard, the results of which we herewith present.

NITRIFYING INDICES.

Three conditions to be recognized in considering the nitrifying ability of a soil are:

1. The nitrifying organisms present.
2. The physical and chemical fitness of the soil for the proper functioning of these organisms.
3. The nitrifying efficiency of the soil and the organisms existing in it.

NITRIFICATION INOCULATING POWER (N I P).

The first index may be called the Nitrification Inoculating Power, which may be abbreviated as N I P. It recognizes only the factor of the live organisms present, taking no account of the fitness or unfitness of the soil for their activity. It does not regard bacterial species, but merely the complex present in the soil at the time it is tested.

Theoretically, the N I P may be high in a soil in which, owing to adverse chemical or physical conditions, no nitrification really occurs. Theoretically, nitrifying bacteria may be present in goodly numbers in a soil possessing physical and chemical conditions favorable to rapid nitrification, yet no nitrate appear, owing to the presence of other species of bacteria or of substances which either inhibit the action of the nitrifiers or destroy the nitrate which

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²Assisted by J. C. Temple, W. A. Syme, J. K. Plummer and P. L. Gainey.

³Stevens and Withers. I—Studies in Soil Bacteriology. Nitrification in Soils and in Solutions. (N. C. Expt. Sta. Rpt. 1907-1908, pp. 40-63.)

they produce, so that nitrate does not appear as a final product. N I P considers only the efficiency of the organisms present to give nitrate as a final product under circumstances favorable to their growth.

NITRIFYING CAPACITY (N C).

The second index, fitness of the soil as regards factors other than its content of living things, *i. e.*, its capacity to support nitrification, provided proper organisms be present, may be designated as its Nitrifying Capacity, abbreviated as N C. N C regards only the nonliving factors. Theoretically, a soil may be of high N C, but still fail to nitrify owing to lack of proper organisms, *i. e.*, to lack of proper N I P. Theoretically, a soil may be of low N C, yet show high N I P. N C will on final analysis be found to depend upon physical conditions and chemical composition, including water content.

NITRIFYING EFFICIENCY (N E).

The third index may be designated as the nitrifying efficiency of the soil, abbreviated N E, which regards the efficiency of the soil as a whole to produce nitrates as a final product. N E may be low owing to lack of N I P or to lack of N C, or both. N E will be high if there be high N I P associated with high N C.

Proper determination of N E will show whether a given soil is in normal vigorous nitrifying condition; if such is not the case, determination of N C and N I P will show whether it is the bacterial or nonbacterial factors which are at fault, and may lead the way to correction of existing defects.

CONDITIONS FOR DETERMINING THESE INDICES.

To make each of these indices of the greatest value the determination must be made as nearly as possible under the conditions that normally obtain in the field. Field conditions are highly variable from season to season, even from hour to hour, and may never be twice exactly alike. They can therefore be only approximated.

Since the soil temperature is extremely variable, sometimes above, sometimes below the optimum for nitrification, it seems best to employ the optimum temperature as standard.

Since the water relation is of dominating importance,¹ the amount of water in the soil cultures should imitate the natural condition of the soil that is to be tested. If this soil be one that is normally saturated or under water, swampy, the cultures should provide these conditions. It is difficult to determine the degree of saturation which best imitates the condition of a normal well-drained field. During and shortly after rain it is saturated. It rapidly dries, and until another rain occurs is considerably below saturation. Since, however, the greater part of the nitrification that does occur must occur during a period approximating the water content, optimum for nitrification, it seems best to use, as nearly as is practicable, this degree of saturation for all soils, other than soils normally saturated as mentioned above.

¹Stevens and Withers. I—Studies in Soil Bacteriology. Nitrification in Soils and in Solutions. Centbl. Bakt. 11 ab. XXIII, pp. 355-373.

PRELIMINARY EXPERIMENTS.

Preliminary experiments were made to ascertain several facts of importance in deciding upon methods, such as the optimum water relation, the effects of different modes of aëration, etc., upon nitrification when soils constitute the medium. The results of these experiments are as follows:

Experiment 2. To determine thermal death point of nitrifying organisms in soil. Forty grams of soil 1867, which had shown nitrifying power, with nitrogen added as asparagin, were put in each of six large test tubes. A tube of this soil was kept in the water bath, which had a temperature of 35°, for ten minutes after the temperature of the soil in a tube under similar conditions had reached 35°. Other tubes were in the same way exposed to temperature of 40°, 45°, 50°, 55°, and 60°.

Six sterile flasks, each of 400 gs. of soil 1867, containing 240 mgs. of nitrogen as asparagin, were then inoculated with the 20 gs. of soil, one flask from each of the tubes, and allowed to stand four weeks, when the nitrate present was determined.

The nitrification resulting was as follows:

Soil heated to 35° contained 27.36 per cent of N as nitrates.

Soil heated to 40° contained 30.28 per cent of N as nitrates.

Soil heated to 45° contained 35.24 per cent of N as nitrates.

Soil heated to 50° contained 38.16 per cent of N as nitrates.

Soil heated to 55° contained 24.28 per cent of N as nitrates.

Soil heated to 60° contained 00.00¹ per cent of N as nitrates.

Check, not inoculated, 000¹ per cent of N as nitrates.

Check, not inoculated, 000¹ per cent of N as nitrates.

It is seen that the thermal death point lay between 55° and 60°, a conclusion in accord with previously reported results.²

Experiment 76. To determine the influence of access of air. Two sets of cultures were made and incubated for four weeks beginning February 27, 1908, one with flasks cotton plugged in the usual manner, one with flasks hermetically sealed. Medium was live soil 1867 and 240 mgs. of nitrogen and cotton-seed meal.

The results are given in Table I.

¹Nitrites and nitrates were tested for with diphenylamine solution. In case there was a coloration after one or two minutes, the amount of nitrites and nitrates was determined by the Teimann-Schulze method. If only a faint coloration appeared, which disappeared upon shaking, a trace was reported; and if no coloration at all appeared, the amount of nitrites and nitrates was recorded as zero. The test was made as follows (Treadwell-Hall Anal. Chem., 1906, Vol. 1, page 340):

"The reagent is prepared by dissolving 0.5 gms. of diphenylamine in 100 cc. of pure concentrated sulphuric acid and adding 20 cc. of water. A few cubic centimeters of the diphenylamine solution are placed in a test tube and carefully covered with the solution to be tested for nitric acid. If the latter is present, there is formed at the zone of contact between the two liquids a ring of beautiful blue color."

Treadwell states that "if one cc. of an acid (concentrated sulphuric S. and W.) which contains only one-twentieth milligram of nitrogen in a liter is used, the reaction will cause a noticeable coloration."

This test is less delicate in water solutions than in concentrated sulphuric acid. Wherever the amount of nitrites or nitrates is recorded in this article as zero small amounts may have been present and escaped detection.

²Lafar Technischen Mykologie, II.

TABLE I—EXPERIMENT 76—EFFECT OF SEALING FLASK UPON NITRIFICATION.

Sample Number.	Condition of Aeration.	Per Cent of Initial Nitrogen Recovered as—		
		Ammonia.	Nitrite.	Nitrate.
2115.....	Sealed.....	35.71	0.00 ¹	0.00 ¹
2116.....	Sealed.....	23.11	0.00 ¹	0.00 ¹
2117.....	Not sealed.....	0.70	Trace	35.39
2118.....	Not sealed.....	0.00	Trace	25.99

The entire absence of nitrification in the sealed flasks quite precludes the use of such flasks in determining nitrifying indices, though for the purpose of avoiding evaporation sealed flasks would be desirable.

To ascertain whether the degree of compactness of the soil in the flask is of influence upon nitrification, cultures were set up with 400 gs. of live soil 1867+240 mgs. of nitrogen as cotton-seed meal or ammonium sulphate. The soil in two flasks was tightly compacted; in two others loosely sifted in; in two others the soil was removed and sifted twice weekly to give more complete aëration. Two other cultures were made in shallow dishes having an area each of 400 sq. cm. to give still more free aëration, but were covered with bell jars to prevent drying. Set up December 15, 1908. Analyses were made at the end of six weeks.

The results appear in Table II.

TABLE II—EXPERIMENT 60—TO ASCERTAIN THE EFFECT UPON NITRIFICATION OF DEGREE OF COMPACTNESS OF SOIL.

Number.	CONDITION OF EXPERIMENT.		RESULTS OF EXPERIMENT.	
	Condition of Soil.	Form of Nitrogen.	Per Cent of Nitrogen Found as Nitrate.	
1991.....	Compact.....	Cotton-seed meal.....	62.6	-----
1992.....	Compact.....	Ammonium sulphate.....	-----	76.1
1993.....	Loose.....	Cotton-seed meal.....	63.6	-----
1994.....	Loose.....	Ammonium sulphate.....	-----	70.5
1995.....	Sifted.....	Cotton-seed meal.....	74.2	-----
1996.....	Sifted.....	Ammonium sulphate.....	-----	73.0
1997.....	In open dish.....	Cotton-seed meal.....	26.0	-----
1998.....	In open dish.....	Ammonium sulphate.....	-----	16.3

The first time this experiment was tried the sealed flasks broke from internal pressure; the second time, escape of gases was provided for by a water seal.

It is seen that with neither of these forms of nitrogen is the effect of the compactness of the soil, as shown in the first six flasks, of much influence upon nitrification under the conditions of the experiment. The low nitrification in the shallow dishes may have been caused by molds which developed to some extent in these cultures.

Experiment 210. September 7, 1908. To determine whether the optimum degree of saturation for pure cultures is the optimum for the bacterial complex of soil 1867. Four-week cultures were made in sterile soil 1867+240 mgs. of nitrogen as ammonium sulphate, with different degrees of saturation, and inoculations were made with suspension from soil 1867 in some instances, with pure cultures of nitrifying organisms in other cases. The pure cultures consisted of a vigorous nitrite former and a vigorous nitrate-former, isolated by the Stevens-Temple Silicate Jelly Plate.¹

They were pure in the sense employed by Winogradsky in that they did not render buillon cloudy. They gave the following nitrogen changes:

TABLE III.

CULTURE OF	GAVE—
Nitrite organism in ammonium solution.....	Nitrite.
Nitrate organisms in ammonium solution.....	No nitrate and no nitrite.
Nitrate organisms in nitrite solution.....	Formed nitrate.
Nitrite organisms in nitrate solution.....	No denitrification.
Nitrate organisms in nitrate solution.....	No denitrification.

The results of Experiment 210 are given in table below.

TABLE IV—EXPERIMENT 210, SHOWING THE OPTIMUM DEGREE OF SATURATION OF SOIL 1867.

Number.	CONDITIONS.			RESULTS.		
	Degree of	Inoculum—Kind.	Amount.	Percentage of Initial Nitrogen Recovered as—		
				Ammonia.	Nitrite.	Nitrate.
2606 ---	One-third ..	Nitrite + nitrate organisms	1 cc. each ..	45.51	0.15	12.53
2607 ---	One-third ..	Nitrite + nitrate organisms	1 cc. each ..	46.35	0.38	11.06
Average ..	.....	.....	.....	45.93	0.26	11.78
2608 ---	Two-thirds ..	Nitrite + nitrate organisms	1 cc. each ..	38.51	1.87	13.16
2609 ---	Two-thirds ..	Nitrite + nitrate organisms	1 cc. each ..	39.21	1.87	12.50
Average ..	.....	.....	.....	38.81	1.87	12.83
2610 ---	Complete... ..	Nitrite + nitrate organisms	1 cc. each ..	44.11	0.07	0.00
2611 ---	Complete... ..	Nitrite + nitrate organisms	1 cc. each ..	44.74	trace	0.00
Average ..	.....	.....	.....	44.47	0.04	0.00
2612 ---	One-third ..	Susp. soil 1867	10 cc.	51.81	0.13	20.98
2613 ---	One-third ..	Susp. soil 1867	10 cc.	54.61	0.12	17.54
Average ..	.....	.....	.....	53.21	0.13	19.26
2614 ---	Two-thirds ..	Susp. soil 1867	10 cc.	56.02	0.10	12.84
2615 ---	Two-thirds ..	Susp. soil 1867	10 cc.	55.45	0.08	12.62
Average ..	.....	.....	.....	55.73	0.09	12.73
2616 ---	Complete... ..	Susp. soil 1867	10 cc.	63.02	trace	0.00
2617 ---	Complete... ..	Susp. soil 1867	10 cc.	broken	trace	trace
Average ..	.....	.....	.....	63.02	trace	0.00

¹Stevens and Temple, "A convenient mode of preparing silicate jelly." (Centbl. Bakt., Sp. II, XXI, 1908, p. 84.)

It is seen that the optimum for the pure culture differs from that of the soil 1867 and that no appreciable nitrification occurred under conditions of saturation with either inoculum.

Experiment 240. To determine the optimum degree of saturation of soil 1931 and the effects of slight variation in water content. 400 gs. of sterile soil 1931+240 mgs. of nitrogen as ammonium sulphate were inoculated with 10 cc. of suspension of soil 1867. Flasks were set up in duplicate carrying water to give 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 per cent of saturation. The results are presented in Table V.¹

TABLE V—EXPERIMENT NO. 240, SHOWING THE OPTIMUM DEGREE OF SATURATION OF SOIL 1931.

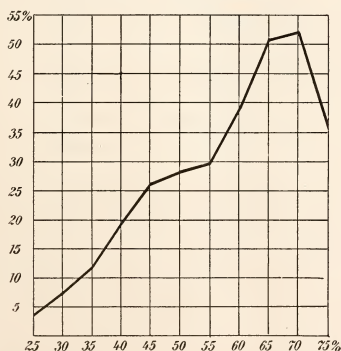
Number.	CONDITIONS.		RESULTS.		
	Water Added.		Percentage of Initial Nitrogen Recovered as—		
	CC.	Per Cent of Saturation.	Nitrites.	Nitrates.	Nitrites and Nitrates.
3128-----	48	25	0.45	2.68	3.13
3129-----	48	25	0.52	4.18	4.70
Average--	48	25	0.49	3.43	3.92
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	0.49	3.43	2.92
3131-----	58	30	0.75	5.51	6.26
3132-----	58	30	0.45	8.32	8.77
Average--	58	30	0.60	6.92	7.52
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	0.60	5.92	6.52
3134-----	67	35	1.50	8.53	10.03
3135-----	67	35	0.60	12.44	13.04
Average--	67	35	1.05	10.49	11.54
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	1.05	9.49	10.54
3136-----	77	40	1.00	18.40	19.40
3137-----	77	40	0.75	18.04	18.79
Average--	77	40	0.88	18.22	19.10
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	0.88	17.22	18.10
3138-----	86	45	1.35	23.39	24.74
3139-----	86	45	1.35	26.21	27.56
Average--	86	45	1.35	24.80	26.15
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	1.35	23.80	25.15
3140-----	96	50	1.20	27.62	28.82
3141-----	96	50	0.45	27.74	28.19
Average--	96	50	0.83	27.68	28.52
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	0.83	26.68	27.52
3142-----	106	55	0.45	28.99	29.44
3243-----	106	55	0.45	29.62	30.07
Average--	106	55	0.45	29.31	29.76
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	0.45	28.31	28.76
3144-----	115	60	1.20	36.28	37.58
3145-----	115	60	1.45	38.64	40.09
Average--	115	60	1.33	37.51	38.84
3130-----	--	--	trace	1.00	1.00
Net-----	--	--	1.33	41.51	37.84

¹Slight corrections have been made in this table since its original publication in the *Centralblatt für Bakteriologie*, etc.

TABLE V—Continued.

Number.	CONDITIONS.		RESULTS.		
	Water Added.		Percentage of Initial Nitrogen Recovered as—		
	CC.	Per Cent of Saturation.	Nitrites.	Nitrates.	Nitrites and Nitrates.
3146.....	125	65	0.30	49.81	50.11
3147.....	125	65	0.30	51.06	51.36
Average..	125	65	0.30	50.44	50.74
3130.....	---	--	trace	1.00	1.00
Net.....	---	--	0.30	49.44	49.74
3148.....	134	70	0.30	52.94	53.24
3149.....	134	70	trace	51.36	51.36
Average..	134	70	0.15	52.15	52.30
3130.....	---	--	trace	1.00	1.00
Net.....	---	--	0.15	51.15	51.30
3150.....	144	75	0.30	36.66	36.96
3151.....	144	75	0.38	34.71	35.09
Average..	144	75	0.34	35.69	36.03
3130.....	---	--	trace	1.00	1.00
Net.....	---	--	0.34	34.69	35.03

These facts are presented graphically in the following curve. It is seen that there is a gradual increase in nitrification with the increase in water content up to 70 per cent of saturation, and that beyond that point nitrification falls off rapidly with increase in water content.



Curve of nitrification at different degree of soil saturation. 1 cm. on the ordinate=5 per cent of initial nitrogen converted into nitrite or nitrate nitrogen. 1 cm. on the abscissa=5 per cent of saturation.

Experiment 211. September 10, 1908. To determine whether the degree of saturation that is optimum for one soil is optimum for others. Three sterile soils of very different saturation capacity were taken; 400 gms. of each were mixed with 240 mgs. of nitrogen as ammonium sulphate, inoculated with 10 cc. of suspension of soil 1867, and incubated four weeks.

The results are given in Table VI.

TABLE VI—EXPERIMENT 211—TO ASCERTAIN WHETHER THE DEGREE OF SATURATION THAT IS OPTIMUM FOR NITRIFICATION IN ONE SOIL IS OPTIMUM FOR OTHER SOILS.

Number.	CONDITION OF EXPERIMENT 211.			RESULTS OF ANALYSIS.		
	Medium— Soil.	Water Added.		Percentage of Initial Nitrogen as—		
		CC.	Degree of Saturation.	Ammonia.	Nitrite.	Nitrate.
2619 ----	1549	30	One-third ----	41.31	0.43	13.57
2620 ----	1549	30	One-third ----	39.91	0.83	14.10
Average ----	1549	30	One-third ----	40.61	0.63	13.83
2621 ----	1549	60	Two-thirds ----	24.51	2.25	24.29
2622 ----	1549	60	Two-thirds ----	24.09	3.37	26.08
Average ----	1549	60	Two-thirds ----	24.30	2.81	25.18
2623 ----	1549	100	Three-thirds ----	50.41	0.10	0.00
2624 ----	1549	100	Three-thirds ----	52.79	0.10	0.00
Average ----	1549	100	Three-thirds ----	51.60	0.10	0.00
2625 ----	1783	48	One-third ----	25.21	0.90	23.49
2626 ----	1783	48	One-third ----	28.01	1.80	21.94
Average ----	1783	48	One-third ----	26.61	1.35	22.21
2627 ----	1783	100	Two-thirds ----	16.80	0.25	23.82
2628 ----	1783	100	Two-thirds ----	22.41	0.37	22.86
Average ----	1783	100	Two-thirds ----	19.60	0.31	23.33
2629 ----	1783	144	Three-thirds ----	63.02	0.10	0.00
2630 ----	1783	144	Three-thirds ----	57.42	0.12	0.00
Average ----	1783	144	Three-thirds ----	60.22	0.11	0.00
2631 ----	1931	60	One-third ----	35.01	0.23	44.79
2632 ----	1931	60	One-third ----	26.01	0.23	46.67
Average ----	1931	60	One-third ----	30.51	0.23	45.73
2633 ----	1931	120	Two-thirds ----			
2634 ----	1931	120	Two-thirds ----	8.40	trace	82.00
Average ----	1931	120	Two-thirds ----			
2635 ----	1931	180	Three-thirds ----	43.41	0.10	trace
2636 ----	1931	180	Three-thirds ----	45.51	0.10	trace
Average ----	1931	180	Three-thirds ----	44.46	0.10	trace

In this case each soil did better in soil culture of two-thirds saturation than in either one-third or complete saturation, though the degree of effect of this factor varies with the different soils, soil 1783 giving results about equal at one-third and two-thirds saturation, while the two other soils show nearly 100 per cent better results at two-thirds than at one-third saturation.

TABLE VII—EXPERIMENT 202. SHOWING EFFECT OF SOIL, *i. e.*, N C. UPON NITRIFICATION.

Number.	CONDITIONS.		RESULTS.		
	Medium.		Percentage of Initial Nitrogen Recovered as—		
			Ammonia.	Nitrites.	Nitrates.
2398-9 ----	Sterile 1867 ----		15.41	trace	17.75
2400-1 ----	Sterile 2250 ----		31.86	trace	0.00
2402-3 ----	Sterile 2404 ----		63.72	trace	0.00

From the last three experiments, considered together, we must conclude that for different soils or different inoculums there are different optima of saturation.

Experiment 202. To show the effect upon nitrification of soils with different N C, set up July 13, 1908. Incubated four weeks, mixed 400 gms. of soil with 240 mgs. nitrogen as ammonium sulphate. Inoculum 10cc. of suspension of soil 1867. The results are shown in Table VII.

It is here seen that the same inoculum failed to induce nitrification in two soils, though it brought about marked nitrification in the other soils, showing clearly the effect of the soil itself upon nitrification, *i. e.*, of the necessity of recognition of what we here term nitrifying capacity (N C).

Experiment 231. To determine whether with different inoculums different rank is given to soils as to their N C. Period four weeks, medium sterile soil 400 gs., nitrogen 240 mgs. as ammonium sulphate.

TABLE VIII—EXPERIMENT 231, SHOWING EFFECT UPON N C OF DIFFERENT INOCULUMS.

CONDITIONS OF EXPERIMENT.				RESULTS.	
Number.	Began Experiment.	Medium Sterile Soil Number.	Inoculum Suspension of Soil.	Per Cent of Initial Nitrogen Recovered as Nitrites and Nitrates.	Rank in N C.
2949-'51	12- 3-08	1549	No. 1867	0.00	-----
2952-'4	12- 3-08	1783	No. 1867	0.00	-----
2955-'7	12- 3-08	1931	No. 1867	9.09	1
2958-'60	12- 3-08	2069	No. 1867	0.00	-----
2961-'3	12- 7-08	1549	Filter bed	5.10m	2
2964-'6	12- 7-08	1783	Filter bed	3.89m	3
2967-'9	12- 7-08	1931	Filter bed	12.85	1
2971-'2	12- 7-08	2069	Filter bed	0.60	4
2993-'5	12-14-08	1549	N. J. soil	0.00	-----
2996-'8	12-14-08	1783	N. J. soil	0.00	-----
2999-3001	12-14-08	1931	N. J. soil	0.00	-----
3002-'4	12-14-08	2069	N. J. soil	0.00	-----
3022-'4	12-21-08	1549	Wis. soil	0.00	-----
3025-'7	12-21-08	1783	Wis. soil	4.36m	2
3028-'30	12-21-08	1931	Wis. soil	6.58p	1
3031-'3	12-21-08	2069	Wis. soil	0.00	-----

m Signifies that the duplicate samples agreed well.

p Signifies that the duplicate samples did not agree well.

It is here seen that though soil 1931 gave the highest N C with each inoculum used, there is variation in N C as determined by the use of different inoculums, since soils 1549 and 1783 failed to nitrify when inoculated with suspension of 1867, though one of them nitrified when inoculated with the Wisconsin suspension and both when inoculated with the filter-bed suspension.

RESULTS OF PRELIMINARY TESTS OF N E AND OF N I P DETERMINED IN SOILS AND N I P DETERMINED IN SOLUTIONS.

THE SOILS TESTED.

The soil from Geneva was sent by H. A. Harding with the statement that it came from a field "which has been in grass for many years, having been

plowed up and borne one crop of corn. The land is of fairly stiff clay and of course well supplied with organic matter."

The soil from New Jersey, supplied by Dr. Lipman, was a red shale "which had been neglected for many years, but which has received thorough cultivation for the last three years." The other was from "an area which has been receiving application of 10-20 tons of manure annually for more than fifteen years."

The soil from District of Columbia, supplied by Dr. Kellerman, was a very rich, black, sandy loam which was said to be of good nitrifying power. The soil from Michigan, supplied by Prof. W. S. Sayer, was a "black soil from a low plat, but well drained. It was used for celery last year and for potatoes this year after a heavy coat of barnyard manure."

The soil from Wisconsin is described by A. R. Whitson of the Wisconsin Experiment Station as follows: "From a field of clay loam soil of glacial drift origin in a limestone region. The subsoil is sandy at a depth of three to five feet. The surface drainage is fairly poor, underdrainage is good. The field has been in alfalfa perhaps three-fourths of the time the past twelve years. During that time it has had top dressings of manure at about fifteen to twenty loads to the acre every three years. It is Plat No. 8 as described in Prof. F. H. King's reports on field work in the annual reports of this Station, from the fourteenth to the twentieth. It has grown two or three other crops of corn and oats."

Two of these soils supplied by Dr. Stephen DeM. Gage were from the sewage filter beds Nos. 1 and 9 of Lawrence, Mass., "which were yielding a highly nitrified effluent."

The Georgia soil, supplied by Mr. J. C. Temple, was from a rich, sandy loam garden.

All of these soils were sent in response to a request for soils most promising as nitrifiers.

Experiments 218, 219, 221. Determination of N E and N I P.

These experiments were conducted after the manner already reported and are sufficiently explained by the accompanying summary.

TABLE IX—SUMMARY OF RESULTS OF EXPERIMENTS 218, 219, 221, SHOWING RELATION N E, N I P IN SOIL AND N I P IN SOLUTION.

Number.	Soil.	N E.	Rank.	N I P in Soil.	Rank.	N I P in Solu- tion.	Rank.
1.....	Filter No. 1.....	32.4	5	12.5	4	5.0	4
2.....	Filter No. 9.....	56.0	4	25.8	2	10.7	1
3.....	Michigan.....	85.2	1	12.2	5	2.9	6
4.....	Wisconsin.....	77.4	2	15.5	3	6.0	3
5.....	New Jersey, H.....	4.6	6	54.0	1	4.4	5
6.....	New Jersey Red Shale....	70.5	3	4.7	6	7.0	2
7.....	D. C.....			8.1m		4.5	

Some of the above tests were made without checks and some without duplicates, and are therefore subject to slight though probably insignificant error.

TABLE IXA—EXPERIMENT 230, SHOWING RELATION N E, N I P IN SOIL AND N I P IN SOLUTION.

Number.	Soil.	N E.	Rank.	N I P in Soil.	Rank.	N I P in Solu- tion.	Rank.
1-----	Filter No. 9-----	37.6	7	49.6	2	12.9	1
2-----	New Jersey, H-----	38.3	6	0.00	5	0.00	6
3-----	Michigan-----	90.31	1	8.45	1	9.79	2
4-----	Wisconsin-----	67.34	3	4.56	3	1.62	3
5-----	New Jersey Red Shale---	62.33	5	trace	4	trace	5
6-----	Geneva-----	65.78	4	0.00	6	1.62	3
7-----	Georgia No. 1-----	80.82	2			0.00	6

¹These determinations were made in duplicate and with checks. Duplicates agreed well.

It is seen in the above summaries that not only does the ordinary solution test fail to give the true rank of the soils in nitrifying power (seen most clearly in the case of the Georgia soil), but that the soil test also fails to do so, indicating clearly that N C plays an important part in determining the N E, and that all that can be had by a soil or a solution test is merely an indication of the bacterial conditions, not a true measure of nitrifying power of the soil in its natural condition.

METHODS FOR STANDARD ANALYSIS.

In the light of these preliminary experiments and of results previously reported, we have formulated the following rules for determining the N E, N I P, and N C of soils. The results of some hundreds of determinations by these methods we shall present in the annual report of the Experiment Station at a later date.

DETERMINATION OF THE N E OF SOILS.

Screen the soil to be tested through a wire sieve, of 3-4 mm. mesh (opening), to remove stones, sticks and coarser matter and to make the soil of good condition to manipulate; then determine its saturation capacity. To do this, 50 grams of soil, present saturation of which is known, are placed on a porcelain plate in a carbon filter and a measured quantity of water, a little more than necessary to saturate the soil, is added, and the effluent is poured upon the soil and allowed to drain through again. This operation is repeated twice to insure complete saturation. The amount of water taken up by the soil is determined by measuring the final effluent and subtracting from the measured quantity originally employed. Allowance is made for water already in the soil.

Weigh live soil equal to 400 gs. of dry soil¹ into a 500 cc. Erlenmeyer flask; add 240 mgs. of nitrogen as sterilized ammonium sulphate solution, with proper precaution against the introduction of germs extraneous to the soil (*i. e.*, using sterile sieves, containers, ladles, washing the hands with nearly surgical care, etc.); add sterile water sufficient, together with that already in the soil, to make it closely approximate two-thirds saturation; plug loosely with cotton; incubate at 30 to 35 degrees for four weeks.

¹Dried two hours at 110°.

Set up in duplicate and with two control flasks, *i. e.*, 400 gs. of the same soil in the same conditions, but without added nitrogen. Make up water loss weekly in all flasks. Determine the amount of nitrite and nitrate present in each flask at the end of the incubation period and report in terms of the element nitrogen.²

Subtract the average of the nitrite and nitrate nitrogen found in the two control flasks to give the *net nitrite and nitrate nitrogen* produced by organisms in the soil in question.

Express the N E as a coefficient equal to the per cent of the original 240 mgs. of added nitrogen that is represented by the net nitrite and nitrate nitrogen found.

When determining the N E for soils normally saturated or immersed, test the soils saturated instead of two-thirds saturated.

DISCUSSION OF N E METHOD.

To strictly reflect field conditions, humidity should be that of the field. Field conditions are, however, variable and such nitrification as does occur takes place mainly at moisture nearly the optimum. We therefore adopt two-thirds saturation as a standard condition for normally drained agricultural soils, and of course a condition of complete saturation for all soils that are normally saturated. Since soils vary in their optimum moisture relation, it would be still better to use the optimum for each separate soil studied. This is, however, manifestly impossible except in case of exhaustive research upon special soils.

The temperature suggested is near the optimum for most nitrifying bacterial complexes and is adopted for substantially the reasons leading to the adoption of the optimum saturation.

The time, four weeks, nearly one-third of a crop-growing season, is ample to give easily measured results in cases of soils in good nitrifying condition. Very poor nitrifiers would give different records with longer time; but this would retard work greatly, probably without affecting conclusions materially.

Aëration is probably better in these test conditions than in the field, but probably not so different as to materially affect results. (See experiment 76.)

That some nitrate is formed in the soils that is not recovered in analysis is certain. This is the chief objection to the use of soils as a medium; but in view of the complete inadequacy of solutions as a medium, there is no escape from the dilemma, and soils must be used.

Experiment 315. To determine the power of water to extract added nitrates from the soil. For this purpose three samples of soil were taken, *viz.*: Nos. 1931, a sandy loam, 3553, a red clay, and 3705, a soil rich in organic matter which had been used for horticultural pot experiments. These soils yielded to water respectively 2.38, 0.92, and 3.72 mgs. nitrogen per 400 gs. of soil. Separate portions of 400 gs. of soil were taken, sodium nitrate was added in amounts which corresponded to various percentages of 240 mgs. nitrogen. The samples were shaken two hours with the usual amount of water and nitrates were determined in the water extracts. These amounts are expressed as follows. Deductions were made of the amounts extracted from the natural soils.

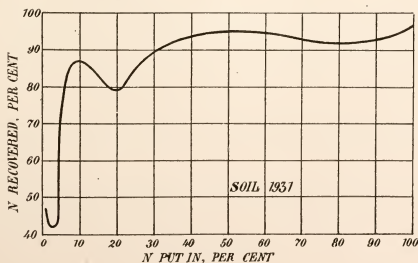
²Stevens and Withers. I—Studies in Soil Bacteriology. Centbl. Bakt. Abt. II, Bd. 23, 1909, p. 355.

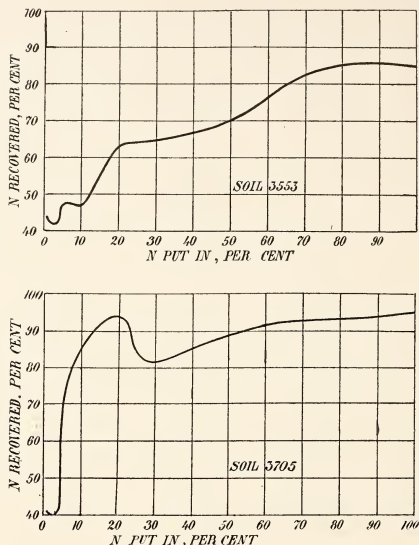
TABLE X—EXPERIMENT 315, TO DETERMINE THE ABILITY OF WATER TO EXTRACT ADDED NITRATES FROM THE SOIL.

Determined.	Nitrogen Added, Percentage of 240 Mgs.	Percentage of Nitrogen Recovered from Soil Number—		
		1931.	3553.	3705.
1.....	1.00	41.66	44.16	40.80
2.....	1.00	53.10	44.16	40.80
Average.....	1.00	47.38	44.16	40.80
1.....	3.00	41.66	42.20	40.00
2.....	3.00	41.66	42.20	40.00
Average.....	3.00	41.66	42.20	40.00
1.....	5.00	69.09	47.33	68.00
2.....	5.00	69.09	47.33	68.00
Average.....	5.00	69.09	47.33	68.00
1.....	10.00	87.70	47.00	87.70
2.....	10.00	84.50	47.00	81.40
Average.....	10.00	86.60	47.00	84.55
1.....	15.00	83.45	54.21	91.93
2.....	15.00	83.45	55.52	91.93
Average.....	15.00	83.45	54.87	91.93
1.....	20.00	79.85	62.65	93.95
2.....	20.00	78.30	64.20	93.95
Average.....	20.00	79.08	63.38	93.95
1.....	25.00	85.20	65.56	84.44
2.....	25.00	83.92	62.64	83.92
Average.....	25.00	84.56	64.10	84.18
1.....	50.00	96.46	68.90	90.20
2.....	50.00	93.96	70.16	89.58
Average.....	50.00	95.21	69.53	89.39
1.....	75.00	92.47	83.92	92.88
2.....	75.00	91.63	83.10	93.29
Average.....	75.00	92.05	83.51	93.09
1.....	100.00	97.09	85.19	95.21
2.....	100.00	97.40	84.56	94.59
Average.....	100.00	97.25	84.88	94.90

These tables show the recovery of only about 40 per cent nitrates when small quantities were added and more than twice this amount when large quantities were added. These results show that figures given elsewhere in this paper are not absolute; but as the percentage recovered increases fairly regularly, the incomplete recovery does not interfere with the conclusions, which have been drawn.

These facts are represented graphically in the following diagrams, which were drawn by L. L. Vaughan:





TO DETERMINE N I P OF SOILS.

Make a bacterial suspension from the soil to be tested, taking 100 gs. of soil to 200 gs. of sterile distilled water, shaking three minutes, sedimenting for five minutes, using the supernatant fluid. All work to be done aseptically. As a medium use the equivalent of 400 gs. of dry standard soil, sterilized, two-thirds saturated, with 240 mgs. of nitrogen added as ammonium sulphate. After inoculation with 75 cc. of the bacterial suspension from the soil to be tested, culture in Erlenmeyer flasks as for the determination of N E.

Do in duplicate and determine the nitrite and nitrate nitrogen present at end of four weeks. From the average of the two flasks subtract nitrite and nitrate nitrogen equal to that in the culture at the beginning, if any, to secure the *net nitrite* and *nitrate nitrogen produced*.

Express N I P as a coefficient equal to the per cent of original nitrogen changed to nitrite and nitrate nitrogen under these standard conditions in standard time. When determining N I P for soils normally saturated, use saturated cultures.

DISCUSSION OF N I P METHOD.

An artificial soil of high N C, which might be universally standard, is desired, but our attempts to construct such an artificial medium have failed utterly.

We recognize that with the use of a different standard soil somewhat different results would be had, but are convinced that the results had by the

method here outlined approach the truth more nearly than earlier methods advocated and employed and give a near approximation to the truth. No one medium can reveal the whole truth.

The standard used by us is our soil 1931, which may be described as follows:

TABLE XI—STANDARD SOIL 1931—CLASSIFICATION, CECIL SANDY LOAM.¹

Gravel over 2 mm. diameter, 2.72 per cent. Mechanical analysis of the fine particles shows the following:

	Diameter mm.	Per Cent.	
1.....	2-1	3.74	Fine gravel.
2.....	1-.5	9.91	Coarse sand.
3.....	.5-.25	9.42	Medium sand.
4.....	.25-.1	32.55	Fine sand.
5.....	.1-.05	13.52	Very fine sand.
6.....	.05-.005	22.07	Silt.
7.....	.005-.0	8.84	Clay.
Total.....		100.05	

A chemical analysis showed the soil to contain:

Moisture.....	7.03 per cent.
Humus.....	2.61 per cent.
Nitrogen total.....	0.082 per cent.
Nitrogen as nitrites.....	0.000 per cent.
Nitrogen as nitrates.....	0.0006 per cent.
Alkalinity in terms of CaCO ₃	0.0074 per cent.
Phosphoric acid.....	Faint trace.

TO DETERMINE N C OF SOILS.

The soil to be tested shall be prepared as for the determination of N E, then sterilized, inoculated, and subsequently treated as for the determination of the N I P; using the same inoculum at the same time in parallel cultures in standard soil. All cultures to be done in duplicate with controls.

The N C is expressed as a coefficient equal to the coefficient obtained by the soil to be tested, divided by the coefficient obtained by the standard soil.

If it were possible to maintain a standard inoculum, the N C could be directly determined, but means of maintaining such an inoculum have not yet been devised.

We recognize here that the use of a different inoculum would lead to somewhat different results, and that tests with no one inoculum can reveal the whole truth.

¹The classification and mechanical analysis were made by G. M. MacNider, Assistant Chemist, N. C. Department of Agriculture.

STANDARD METHOD REGARDING AMMONIFICATION.

For the same reason set forth regarding nitrification, we believe that the ends of soil bacteriology will be furthered by the adoption of similar indices regarding the soil factor of ammonification. We therefore propose the terms Ammonifying Efficiency (A E), Ammonifying Inoculating Power (A I P) and Ammonifying Capacity (A C), to be determined in the following ways:

To Determine A E.

The sample to be prepared and tested as for N E, with the exception that 200 gs. of soil be used and that nitrogen 120 mgs. be added as cotton-seed meal instead of as ammonium sulphate; incubation to be for seven days; analysis to be for ammonia.¹

To Determine A I P.

The sample to be prepared and tested as for N I P, except that nitrogen be added as cotton-seed meal medium 200 gs. inoculum 25 cc. and that incubation be for seven days and analysis for ammonia.

To Determine A C.

The sample to be prepared and tested as for N C medium 200 gs., the inoculum to be 1 cc. of a pure culture of *B. Subtilis* twenty-four hours old in standard beef bouillon at incubator temperature, which culture was inoculated with one oese from another culture. This inoculum to be frequently standardized against standard soil and corrections made for any change from its original ammonifying power.

¹For methods see Stevens and Withers, II—Studies in Soil Bacteriology. Centbl. Bakt. ab. II, Bd. 23, 1909, p. 776.

[PRESS BULLETIN, No. 16, SEPTEMBER 1, 1908.]

SELECTING SEED CORN FOR LARGER YIELDS.

By C. B. WILLIAMS, DIRECTOR.

The practice of selecting seed corn from the barn late in the spring costs the farmers of North Carolina, in decreased yields of shelled corn, an amount equal to more than five million dollars annually. Just so long as this method is followed, just so long will the corn growers of the State lack this amount of producing what they might with the same treatment under identical conditions were they to use better methods in the selection of their seed corn. The proper place to select seed for planting purposes next year is in the field this fall. One day spent in the field in selecting seed corn properly will pay better in increased yields than most any labor performed during the entire year. There are many ways in which this work might be done satisfactorily, the exact method depending upon local conditions and practices. Economy of performance of the operation is always to be looked after, but not at a sacrifice of efficiency. Where corn is gathered from stalks in the field in the usual way, a good method for the corn grower to use is to sling a cotton-picking bag over the shoulder or take a basket in the hand and go through and make the selections from the field of corn which he has that is a little above the average in productivity. Take two rows at a time and select seed from those stalks which have two well-developed ears per stalk, remembering that in the selection of seed one should select from the stalks that will yield the largest amount of shelled corn per stalk. The reason why it is advised selecting from two-eared stalks is because in testing and studying varieties of corn during the past eight years on the Experiment Station farm, and elsewhere, it has been found that the best yielders of shelled corn per stalk, and hence per acre, were those that averaged near two ears per stalk. Take both of the ears if they are good ones, and reject both if they are not. Do not give much detailed attention to the shape of the ears and grains during field selection, but reserve this for some rainy or snowy day during the winter and have the young boys around to help, as there is no form of farm work that will interest them more or lead them to take a deeper interest in the work of the farm. One reason why so many boys leave the farm is because they are not taught that there is something more in farming than the mere drudgery connected with it. When going through the field selecting these ears it might be well to have the boys along too, if they are old enough to appreciate the value and importance of what is being done. A cart or wagon might be at one end of the rows and when you get there each time empty the basket or bag. Enough corn should be gathered in this way so that when the more careful selection is made during the winter at the barn, having in mind the best shape of ears and kernels, enough will be left for planting, after throwing out the ears of poor shape and those having kernels not up to the proper type it is wished to use for planting. Select from the field three to five times as much corn as it is expected to be needed, so that a very rigid selection of the ears may be made during some winter day. Make selections from

stalks that not only bear two well-developed ears, but from those that have a good leaf development and large root system. Select ears that are borne at a uniform and convenient height, for such ears are more easily and cheaply gathered, they ripen more uniformly, and are less liable not to have the embryo grains fertilized, as the tasselling of all stalks will be practically at the same date and the pollen from all will be given off at about the same time. The ears should be held not upright, but in a rather drooping position, as such ears are less liable to rot, as they will shed the rain rather than admit it into the ears, as they frequently do when held in an upright position; especially is this so if the husks (shucks) do not cover the tips of the ears completely. Also, it is well to discard all ears that have the tips poorly covered with husks, even if all the other characteristics are up to requirements. When, during the winter, the corn thus gathered is gotten out for more careful selection, choose those ears of cylindrical shape and those which possess deep wedge-shaped and large-germed grains which completely and deeply cover the cobs and which are arranged in parallel rows. Select heavy, well-matured ears that have medium-sized cobs with kernels that are heavy in weight and medium rough in indentation, and which have the butts and tips fairly well filled out. Keep the seed stored in a dry place until planting time.

If you have not selected your seed corn before from the field in the way indicated above, try it this fall. You may be a little doubtful of the value of this extra effort, but give it a fair trial and we feel sure that you will never go back to the old and less profitable method of selecting seed corn from the barn.

[PRESS BULLETIN, NO. 18, FEBRUARY 15, 1908.]

THE APPLE BITTER ROT.

By F. L. STEVENS, BIOLOGIST.

Occurrence in North Carolina.—This disease occurs in very destructive form throughout the Piedmont and eastern sections of the State, though it is possibly less destructive further west. In a recent trip through the middle section of the State the writer saw dozens of orchards ruined by this rot which, but for the presence of it, would have yielded largely. In many of the orchards visited the trees were in fine condition, showing suitability of soil and climate, and they bore an abundance of fruit, but closer examination showed that the ground under the trees was completely covered with rotten apples and that the apples still on the trees had numerous specks of soft, brown rot. In many villages and towns all apples offered for sale in stores were affected with this rot.

The facts as stated above show the very destructive prevalence of this disease in this State.

This rot has been known in destructive form in the United States since 1867. It is estimated to have done \$1,500,000 of damage in four counties in Illinois in 1900. In the Middle States the losses are estimated to be from one-half to three-fourths of the entire crop. The President of the National Apple Shippers' Association estimated the damage in the United States in 1900 at \$10,000,000.

Description of the Bitter Rot.—There are many different types of apple rot—some are hard, some soft, some wet, some dry, some of one color and some another, etc. The bitter rot of the apple, sometimes called the ripe rot, is a soft, wet, yellow rot, occurring usually as circular spots on the fruit. These spots, of which there may be from one to twenty or more on each apple, enlarge rapidly, run together, and the whole fruit becomes a soft, rotten mass. The disease usually begins while the fruit is still hanging on the tree, and as the disease progresses, many of the apples fall to the ground below.

Cause of the Rot.—This rot is caused by a fungus, known as *Glæosporium*, the spores of which fall upon the apple, grow, penetrate it, and cause the decay. The spores are produced in immense quantities in small pustules, which appear upon the rotted surface. In many instances the fungus passes the winter in cankered spots on the twigs and bark.

Treatment.—There are two forms of treatment, both of which should be followed.

First, inasmuch as the fungus is known to winter in the canker on the branches, it is important when the leaves are off the trees to carefully inspect the orchard, hunt out these cankers, cut them out and burn them, and thus remove the most dangerous source of spring infection.

Second, the trees should be sprayed with Bordeaux Mixture in order to kill all spores which fall upon the fruit or twigs. Spraying should be applied before the buds begin to swell in the spring, just after the blossoms fall, and every ten or fourteen days thereafter until the fruit is almost ripe.

These two treatments combined will, to a very large extent, serve to control this very serious disease.

[PRESS BULLETIN, No. 19, NOVEMBER, 1908.]

SUPPRESSION OF TERRAPIN BUGS.*(Also known as Fire Bugs, Calico Bugs, Harlequin Bugs, and Collard Bugs.)*

BY R. I. SMITH, ENTOMOLOGIST.

SOME IMPORTANT FACTS.

As the remedial measures given below are based upon certain vulnerable points in the life-history of this insect, the following important facts are given:

1. Terrapin bugs hibernate during winter in the adult stage.
2. They may now be found on collard, turnip, cabbage, kale, and other cruciferous crops, as well as occasionally on other plants.
3. Terrapin bugs feed on the plant juices, obtained by means of a slender pointed beak. Hence they cannot be poisoned with arsenical sprays like Paris green.
4. Each individual may lay from ten to fifteen masses of twelve eggs each, or from one hundred and twenty to one hundred and fifty-six eggs. Occasionally a greater number are laid.
5. The period of egg-laying lasts about two months. In spring, the eggs require about eight to eleven days to hatch, but only three to four in hot weather.
6. THERE ARE ONLY THREE FULL BROODS ANNUALLY, but some bugs in all stages of development may occur in the fields as late as November.
7. THE BUGS WHICH BECOME ADULTS AFTER ABOUT SEPTEMBER 1 DO NOT LAY EGGS THE SAME FALL, but live over winter and produce the first spring brood.
8. Every adult female terrapin bug destroyed this fall might, if allowed to live, produce over one hundred bugs next spring.

WHY THE ABOVE FACTS ARE OF VALUE.

The above facts are pertinent, and some, especially NUMBERS 4, 6, AND 7, ARE NEW, and have been obtained by the writer as a result of a careful study of the terrapin bug—its habits and life-history—during the present year. This work shows quite conclusively that the farmer has a good opportunity to prevent a large part of the annual loss of thousands of dollars caused by the deterioration in the value of crops attacked by this destructive pest. The opportunity centers on the fact that all bugs maturing after about September 1 do not lay eggs the same season. If all adult bugs present during September, October, and November did lay eggs continuously, it would be a never-ending task to collect or to destroy them by spraying. The mature bugs are not easily killed by a contact spray like kerosene emulsion, although it will kill most of the young ones. Only a few eggs would be killed by spraying.

These facts are presented at this time in order to stimulate farmers and gardeners to fight the terrapin bugs now during the first days of November. It matters not whether the bugs are present in small or large numbers. It is certain that the bugs will have to be fought next spring and summer if they are not destroyed now; and just consider how much easier it is to catch and kill one terrapin bug at this time than it will be to wait and destroy her progeny next spring, numbering, perhaps, over one hundred.

HOW TO DESTROY THE BUGS.

In the opinion of the writer, there are only two effective methods of destroying terrapin bugs: one being hand picking and death by crushing or dropping in kerosene, and the other the use of a contact spray like strong kerosene emulsion, that will kill all the bugs it can be made to touch.

Hand Picking.—Unless the bugs are very numerous, hand picking is the most practical remedy. Children may do the work as well and even faster than grown persons. The bugs may be collected quite rapidly by picking all in sight and then shaking the plants and collecting those that drop. This work should be done on warm, sunny days, when the bugs are not in hiding, and one should not expect to get all at the first picking. Go over the infested plants two or three times, and on different days. The results from one thorough picking will, however, fully repay the farmer for his time and cost.

In fields in which the infected crop is of no further value, the plants may be pulled and piled in small heaps and left a couple of days until the terrapin bugs congregate on them, when the bugs may be readily killed by burning or treatment with pure kerosene. Be sure that the bugs are destroyed before they migrate to other feeding grounds.

Spraying the Crop.—This method is of some value, but is not strongly recommended for use at this time of the year. Kerosene emulsion at 25 to 30 per cent strength will kill many bugs, if it can be applied so as to cover them thoroughly. It is recommended mainly, however, for killing the small or half-grown bugs during summer. Where bugs occur on worthless plants, pure kerosene may be used with good results so far as killing the bugs is concerned, but the expense will often be more than would be required by hand picking.

By following the directions given above, thousands of dollars will be saved annually to North Carolina farmers.

[PRESS BULLETIN, No. 20, FEBRUARY, 1909.]

SPRING DESTRUCTION OF TERRAPIN BUGS.

BY R. I. SMITH, ENTOMOLOGIST.

The annual loss caused by terrapin bugs sucking the life out of collards, cabbages, turnips, and allied plants is difficult to estimate accurately, but certainly amounts to thousands of dollars in North Carolina. A large proportion of this loss may be prevented if farmers, gardeners, and truckers will take the trouble to collect or in some way destroy the bugs that first appear this spring. We have conclusive evidence that such work may be made a paying investment. We cannot, however, continue to wait, as is usually done, until the bugs become so numerous as to cause very noticeable injury in gardens or fields, but on the contrary they must be destroyed before they commence to lay eggs; otherwise the annual loss will remain the same or will increase.

In November last this Station published a press bulletin urging farmers to immediately collect and kill the terrapin bugs, then in their fields, to prevent their living in such numbers through the winter. Now it seems advisable to urge the equally important work of destroying those individuals that escaped last fall, and which will soon commence to come out from their winter hiding quarters.

ONLY ADULT BUGS SURVIVE THE WINTER.

Eggs and young bugs do not live through the winter in this State; hence it is only full-grown, strong, adult males and females which survive by finding favorable hibernating quarters under rubbish around the gardens, under stones, in fence corners and similar places, where they are protected from the weather. As this has been a mild winter, they are liable to appear in greater numbers than usual in the spring.

WHEN EGG-LAYING COMMENCES.

We could not consistently urge the task of destroying the overwintering bugs if they commenced to lay eggs upon their first appearance. Careful observation has shown that at least two weeks' time elapses after the bugs appear before the first eggs are deposited. During this period they are very actively feeding and mating, and the majority will congregate on the few old plants left from last season's crop. Wild mustard and turnips are favorite food plants, and collards, with their broad leaves, often harbor a large number of them.

The prime object of this article is to emphasize the fact that the farmer or gardener who watches closely for the first terrapin bugs to appear has about two weeks' time to kill them and still prevent the majority from laying eggs for the first generation.

RATE OF INCREASE.

Have you ever considered the actual benefit that results from killing one female terrapin bug when she first appears in spring. Observe the following statements: The average number of eggs laid by each bug varies from eighty-

four to ninety-six—that is, seven or eight masses of twelve eggs each, deposited over a period of from four to eight weeks. There are three full generations each year. Suppose we kill a single terrapin bug and thus prevent ninety-six young for the first generation, of which one-half might be females. If these forty-eight females reproduced at the same rate, the second generation would number 4,608 individuals. Counting only one-half as females, each capable of producing ninety-six young, the third generation would reach the enormous number of 221,184, the progeny of one female in a single year. We can divide this number by one hundred and still have over 2,200 as the number of bugs prevented by killing one individual when she first appears.

During the warm summer months a minute parasite in the form of a tiny black fly destroys a large percentage of the eggs, but as a general thing these parasites do not become abundant until the first generation is well developed; so that the destruction of the bugs that produce the first generation is more essential than the death of bugs later in the year. Another point in favor of early destruction.

Are not the above facts sufficient to impress farmers with the importance of spring destruction of terrapin bugs?

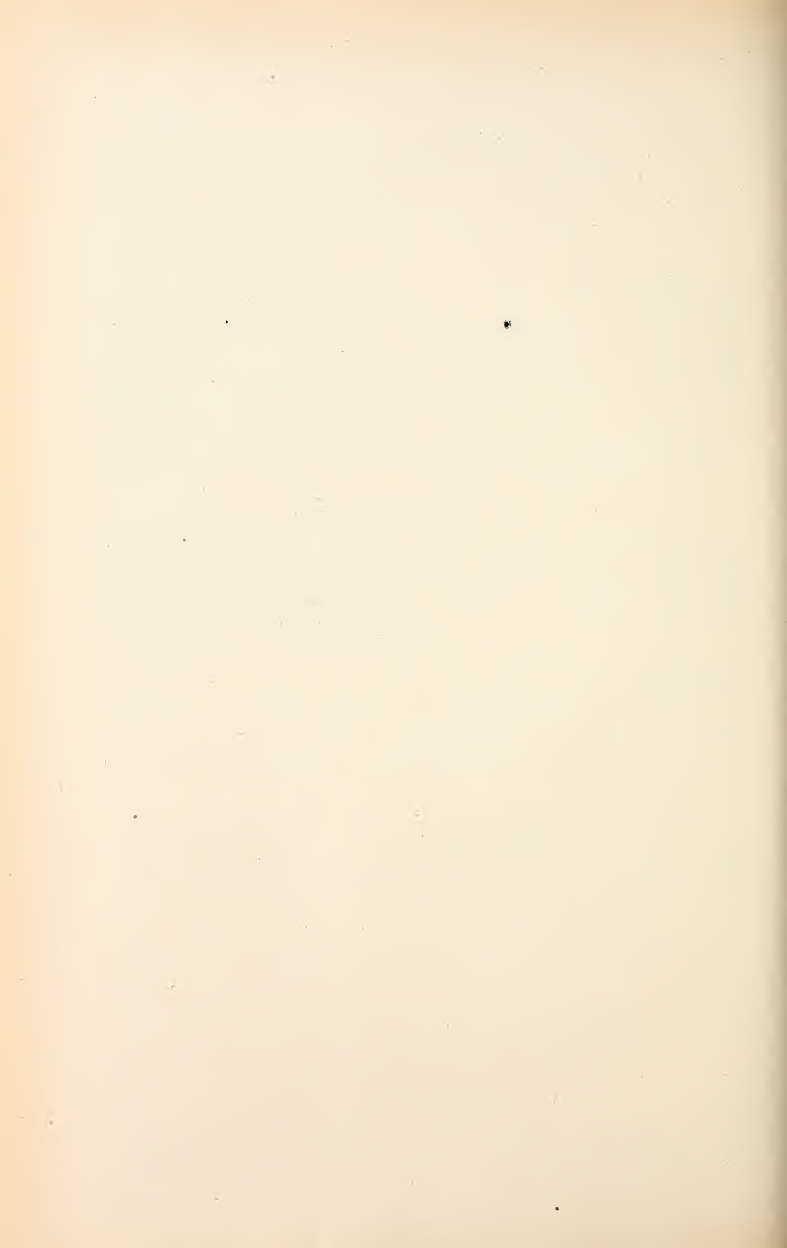
HOW TO DESTROY THEM.

Hand Picking.—This is probably the most valuable method of killing terrapin bugs at any season of the year. The work can be done rapidly by children. The bugs are inclined to hide on cold, windy, or dark days; so that warm, sunny days should be selected for this task. We cannot expect to find all the bugs in one day, or even the majority of them. A good plan would be to collect two or three times a week, but be certain to commence within a few days after the bugs first appear. They may be killed by crushing or by dropping in a little kerosene.

Spray with Pure Kerosene.—When the bugs are abundant on worthless plants they may be killed with pure kerosene. With the aid of a small spray pump a large number of bugs may be killed in a few hours.

Arsenical poisons are not effective against this insect, which feeds by sucking the plant juice.

Kerosene emulsion of 15 or 20 per cent concentration is used with success for killing small or half-grown bugs, but this treatment will not kill many adults. By following the suggestions made above, the young bugs will not become numerous, but whenever spraying does become necessary kerosene emulsion is the best remedy to use.



NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

**COLLEGE OF AGRICULTURE AND
MECHANIC ARTS**

WEST RALEIGH

**FEEDING FERMENTED COTTON-SEED
MEAL TO HOGS.**

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,
UNDER THE CONTROL OF THE
TRUSTEES OF THE A. AND M. COLLEGE.

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

	PAGE.
Summary	4
Introduction	5
Object of experiment.....	5
Weight of animals, feeds and rations.....	6
Commercial value of feeds.....	7
Preparation of feeds.....	8
Conditions of experiment.....	8
Comparison of results by tables, with illustrations.....	9
Discussion of results.....	11
Gains by periods.....	14

SUMMARY.

Corn alone proved to be an undesirable ration for growing hogs, causing small gains and unthrift. This condition was more marked, owing to the fact that the lot was closely penned, without pasture; yet the other lots, similarly confined, made relatively larger gains.

Fermented cotton-seed meal can be fed in small quantities for limited periods, with very gratifying results. These experiments indicate that seventy-five to ninety days would be the limit of satisfactory feeding. This would depend, however, on the age and condition of the hogs, the supplementary feeds and the proportion of cotton-seed meal fed.

Lot 3, fed a combination of corn and cotton-seed meal, in the proportion of four to one, made larger and cheaper gains for the first ninety days than the lot similarly fed on corn and linseed meal. This would seem to indicate that, when possible, cotton-seed meal should be used, since it contains a larger quantity of protein and sells for about one-fourth less per ton than linseed meal.

Farmers would, according to the results of this experiment, be safe in feeding fermented cotton-seed meal to seventy-five-pound shoats in quantities ranging from one-sixth to one-fifth the total ration, by weight, for a period of seventy-five to ninety days.

The feeding of the four lots of hogs during the first period was more profitable when one part of cotton-seed meal was added to the ration of four parts corn than when corn alone or corn and linseed meal in combination were fed. In case of linseed meal, however, the greater cost of gain was due to the high price of the feed, and not so much to its lack of efficiency in making gains. Barring this one factor, and the possible danger in feeding cotton-seed meal, the two feeds, according to the results of this experiment, are approximately the same in feeding value when fed for the time stated.

With corn and cotton-seed meal each costing approximately \$28 per ton, the results of this experiment show clearly in favor of the combined corn and cotton-seed meal ration, considering always the limitations given as to the amount fed and length of feeding period. While Lots 2, 3 and 4 have had a somewhat larger ration than Lot 1, the larger gains during the first period were sufficient to considerably overbalance this factor.

The practical application of these results would not be to feed under the conditions here described, but rather to feed the corn and cotton-seed meal in connection with grazing crops, which can be produced so abundantly by Southern farmers. This experiment was carried on under adverse conditions to render safe conclusions possible.

When fed with judgment, cotton-seed meal can be made a valuable adjunct to corn as a ration for hogs. It is our cheapest commercial feed supplying protein, and should not be entirely ignored in swine production.

Cotton-seed meal, when fed in quantities, as given in this Bulletin, will, after a time—one hundred to one hundred and twenty days—apparently reduce the normal gains and profits therefrom. This point should be kept in the mind of the feeder, the amount of feed used recorded, and the hogs weighed occasionally. Accurate judgment will direct when to eliminate the meal from the ration. Aim to feed under the limit, however, rather than over.

FEEDING FERMENTED COTTON-SEED MEAL TO HOGS.

BY R. S. CURTIS, ANIMAL HUSBANDMAN.

The Experiment Station has frequently been questioned in regard to feeding cotton-seed meal to live stock. A large number of these inquiries relate to swine and the practicability of feeding cotton-seed meal to these animals. While this is not a new question, and we are aware that cotton-seed meal fed to swine in moderately large quantities is unsafe, frequently causing death, yet it seems highly desirable, when possible, to combine cotton-seed meal with high-priced corn, which is so generally used throughout the State. In making this combination of feeds, which seems especially desirable for growing hogs, because of the high protein content of cotton-seed meal, the feeder should be judicious in his methods and should be guided by the results obtained in this and other experiments reported. In the hands of a careful feeder, fermented cotton-seed meal may be used in small quantities, for a limited time, with good results, but for the indifferent and shiftless feeder it will most likely prove fatal to the growth and health of the animals, and if fed to extreme death will almost invariably result. While no deaths were recorded during this experiment, it is evident, as shown by the results in Table 1, that the last period of feeding was not as satisfactory as the first. The gains were much less and the cost more per pound of gain, and it is possible that the health of the animals might have been materially injured had the experiment continued for a longer time. Nothing definite can be stated in this regard, however, as the hogs were apparently normal when the experiment was completed.

OBJECT OF EXPERIMENT.

1. The experiment was conducted primarily to determine the amount of fermented cotton-seed meal which might be fed with economy and safety, in conjunction with corn, to young and growing hogs.
2. To determine the economy of gain from feeding cotton-seed meal in the proportions specified, and in comparison with corn alone, and with corn and linseed meal combined.
3. To determine the quality of the product produced by the different rations. This portion of the work will be reported in a subsequent BULLETIN.

WEIGHT OF ANIMALS, FEEDS AND RATIONS.

The average weight of the hogs at the beginning of the experiment was approximately 70 pounds. The rations fed to the four lots of hogs during the first period were as follows:

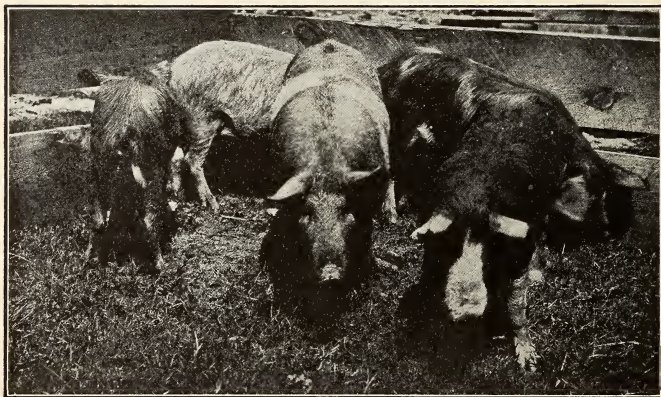
Lot 1. Corn.

Lot 2. Corn, 7 parts; cotton-seed meal, 1 part.

Lot 3. Corn, 4 parts; cotton-seed meal, 1 part.

Lot 4. Corn, 4 parts; linseed meal, 1 part.

The feeding was all done in dry lots, measuring 10 x 40 feet, and during a considerable portion of the time the weather was quite unfavorable for large gains. The quality of hogs was not of the best. They were of mixed blood, yet the division into lots was made in such a manner that practically all individuality was overcome. The low grade of the hogs accounts in part for the generally reduced gains obtained, although there were other unfavorable factors. From a comparative standpoint, however, the results are quite conclusive.



Lot 1.—Fed first period, corn alone; and second period, mixture of 4 parts corn and 1 part linseed meal.

On March 29, the end of the first period of three months, the rations were reversed and the lots of hogs were fed as follows:

Lot 1. Corn, 4 parts; linseed meal, 1 part.

Lot 2. Corn, 4 parts; cotton-seed meal, 1 part.

Lot 3. Corn, 7 parts; cotton-seed meal, 1 part.

Lot 4. Corn.

By reversing in this manner, Lots 2 and 3 still remained on the cotton-seed meal ration, since it was not desirable to cut off this part of the experiment, as one of the objects was to determine the amount

of fermented meal which could be fed and the length of time this could be continued without the development of unfavorable results.

It is also important to know just when cotton-seed meal begins to show a detrimental influence on the health and thrift of the pig.

By reversing Lots 2 and 3 in the manner indicated, Lot 3 received all during the feeding trials a ration which conforms fairly accurately with our present idea of rational feeding. During the first part of the period the cotton-seed meal was fed in larger quantities to stimulate the growth of bone and muscle, while in the last period of fattening it was reduced just enough to balance the corn ration and at the same time keep within the bounds of safe feeding.

On the other hand, Lot 2 was fed only seven parts of corn with one part of cotton-seed meal during the first period, the results being less satisfactory than those obtained from Lot 3 during this period, as shown by Table 1. After reversing the ration and placing Lot 2 on a larger amount of cotton-seed meal, thus subjecting them to the meal gradually, the results were somewhat more satisfactory than those obtained during the second period of Lot 3, from the standpoint of the amount of feed eaten, pounds of feed used per pound gain, and cost of the gains. There was not enough difference, however, to warrant definite conclusions, as indicated by Table 1. The total gain made during the feeding period of six months was in favor of Lot 3, fed the larger quantity of cotton-seed meal during the first period. The results indicate that the linseed meal stimulated a relatively larger gain during the second period with Lot 1 than was made during the first period with Lot 1 when fed on corn. The corn alone caused larger gains during the second period with Lot 4 than was made with either Lots 2 or 3 during the corresponding period, when the hogs were fed cotton-seed meal as a supplement. This would seem to indicate that an all-corn ration is more effective in making gains during this period of feeding, and that either the nitrogenous supplement is not needed or the cotton-seed meal is detrimental after a certain stage of feeding.

During the feeding period of six months no signs of sickness were evident, and the increased gain made by Lot 3 during the first period shows plainly the desirability of adding limited quantities of the fermented cotton-seed meal to the ration for the length of time given in the results.

The hogs were weighed each week during the experiment, and a fairly substantial gain was made, especially during the first period, in favor of Lots 3 and 4.

COMMERCIAL VALUE OF FEEDS.

In placing a value on a feed stuff it is customary to take into consideration the actual cash value of that feed on the market. It is a fact, however, that if the farm products are fed and the manure placed

on the land any man could afford to take actually less than market value when the same is marketed in the form of pork, and retain the manure on the land rather than sacrifice this valuable material. It should be the aim always to market home-grown products in the form of beef, pork or mutton, and thereby secure the increase over the market price of the feed, when the conditions are such as to make it possible.

In rating the feeds used in this experiment, the common practice has been followed of figuring them at the exact market value at the time the experiment was conducted. This was necessary, as no provision was made for determining the value of the manure at the time the experiment was planned.

The prices assigned to the different feeds were, for corn, \$28; cotton-seed meal, \$28, and for linseed meal, \$35 per ton.

This places the cost of gains at a maximum figure; but if we were to actually determine the enhanced value to the land, where the hogs are properly bedded and the manure conserved and applied to the land, the cost of production would be materially reduced.

PREPARATION OF FEEDS.

During the winter months it was necessary to prepare the rations from two to three days in advance of feeding, in order to have them thoroughly sour. After the weather became warm, however, twenty-four to thirty hours were generally sufficient to bring about the desired condition. In preparing the feeds the shelled corn and combinations of cotton-seed meal and linseed meal with corn were weighed out into tin buckets, in the proper proportions, well mixed, covered with water and stirred thoroughly. The buckets were then placed on a shelf and allowed to stand until the rations were fed. The feeds for the four lots were all given the same fermentative treatment, as it was necessary to do this in order to correct any favorable or unfavorable results which might arise from soaking and fermenting the cotton-seed meal rations for Lots 2 and 3.

In every case, with the exception of Lot 1, the feeds were eaten with apparent relish. With this lot, however, a dull, stupid condition and depressed appetite developed with all the pigs after a lapse of three or four weeks.

CONDITIONS OF EXPERIMENT.

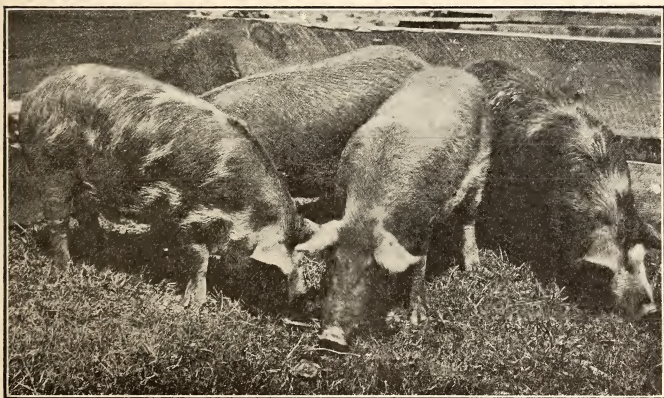
The experiment proper was conducted for six months, beginning January 29 and ending July 29, 1908, and was divided into two periods of three months each. At the beginning of the second period the rations were reversed.

For the first three months of the final feeding period six pigs were used in each of the four lots, but during the last three months only

five were used, because two "piggy" sows had to be removed from two of the lots. To balance this, one pig was taken from each of the other lots.

In making the division great care was taken to divide the hogs into lots of as nearly the same weight and type as possible, in order to eliminate individuality.

The pigs were all closely penned during the experiment—a condition most unfavorable for large gains with young hogs. The gains, without doubt, would have been greater had the hogs been allowed a run on green pasture; but as it was the desire to place them under the most unfavorable conditions, owing to the peculiar nature of the experiment, they were penned in dry lots. During the first feeding period especially, the muddy condition of the lots was partly responsible for the decreased gains made with the hogs as a whole.



Lot 2.—Fed first period, mixture of 7 parts corn and 1 part cotton-seed meal; and second period, mixture of 4 parts corn and 1 part cotton-seed meal.

COMPARISON OF RESULTS BY PERIODS.

The following table shows in a concise way the points of special interest brought out by feeding the four lots of hogs. The illustrations show quite clearly the marked differences in the quality of the lots. This is very strikingly shown in the case of Lot 1, which was fed on corn alone. The condition of the lot, as indicated in the cut on page 6, shows all evidences of unthrift. In case of Lots 2, 3 and 4 the difference is not so marked, although Lots 3 and 4 are smoother and more uniform throughout. The photographs were taken shortly before the conclusion of the experiment.

A close observation of the cuts by the reader may make it seem that the hogs in Lot 1, fed on corn alone, were decidedly inferior in quality. This was not the case, however, as particular efforts were given to the matter of selecting the hogs in each lot as uniformly as possible. The division was made according to weight, type and quality, which were distributed equally. An examination of the records will show that the weights of all lots were practically identical at the beginning of the experiment. The condition of the animals was also quite uniform. Outside of the different supplementary feeds used, the treatment of the four lots was the same. All were confined in feeding pens, where they were fed three times each day—morning, noon and night; and throughout the experiment a mixture of ashes, charcoal, lime, sulphur, copperas and turpentine was fed three times per week. The unthrifty condition of Lot 1 developed gradually, becoming especially noticeable after the first three or four weeks of feeding. As the pigs in this lot refused to eat their ration, it was reduced at times to an amount so small that one good, thrifty hog would have readily eaten it.

TABLE 1—SHOWING KIND AND PROPORTION OF FEEDS, WEIGHT OF HOGS AT BEGINNING AND END, AMOUNT OF FEED EATEN, AND COST OF GAIN.

	First Period—90 Days.				Second Period—91 Days.			
	Lot 1—Fermented Shelled Corn.	Lot 2—Fermented Shelled Corn and Cotton-seed Meal.	Lot 3—Fermented Shelled Corn and Cotton-seed Meal.	Lot 4—Fermented Shelled Corn and Linseed Meal.	Lot 1—Fermented Shelled Corn and Linseed Meal.	Lot 2—Fermented Shelled Corn and Cotton-seed Meal.	Lot 3—Fermented Shelled Corn and Cotton-seed Meal.	Lot 4—Fermented Shelled Corn.
Proportion in which feeds were fed-----	Corn Alone.	7:1	4:1	4:1	4:1	4:1	7:1	Corn Alone.
Average weight in pounds at beginning -----	73.30	75.30	75.30	75.10	97.40	122.00	141.40	135.00
Average weight in pounds at end -----	89.50	116.60	132.00	129.10	117.00	144.00	164.00	168.00
Average gain per head by periods-----	16.20	41.30	56.70	54.00	19.60	22.00	22.60	33.00
Average daily gain in pounds per head-----	.18	.46	.63	.60	.21	.24	.25	.36
Total pounds of feed eaten per pig-----	208.04	275.50	289.37	289.37	164.65	235.97	270.80	261.20
Average number pounds of feed consumed daily per pig	2.31	3.06	3.22	3.22	1.81	2.59	2.98	2.87
Pounds feed eaten per pound gain -----	12.84	6.67	5.10	5.36	8.40	10.72	11.93	7.91
Average number pounds of supplementary feed eaten daily per pig-----	.00	.38	.62	.62	.33	.46	.37	.00
Total number pounds of supplementary feed eaten per pig-----	.00	34.44	55.25	55.25	29.80	41.65	33.85	.00
Cost in cents per pound gain--	18.00	9.33	7.14	7.86	12.30	15.00	16.70	11.07

DISCUSSION OF RESULTS.

The corn ration fed to Lot 1 proved to be very unsatisfactory. This ration is fed, however, to young hogs, in the majority of instances, in this State; and from the large number of bulletins which have already called attention to the excessive cost of production from feeding young hogs on corn alone, it seems as though the information should be widespread, and that farmers would be eager to discontinue the practice. Many farmers, however, are yet feeding high-priced corn to breeding and growing hogs, in the face of these facts.

The gain made by the six hogs in Lot 1 was 97 pounds during the first period. This is very little more than one good, thrifty shoat should have made in the same time, granting that the ration was made from proper feeds, containing sufficient protein and ash for muscle and bone production.

It required 12.84 pounds of feed to produce one pound of gain, representing a cost of 18 cents per pound. The average gain per day was only .18 pounds, whereas it should have been at least one-half or two-thirds of a pound, with a properly balanced ration.

During the last period, after changing the ration to a mixture of corn and linseed meal, the average gain per day was greater than during the first period. It required 8.4 pounds of feed to produce a pound of gain, one-third less than during the former period, which represents a cost of 12.30 cents per pound of pork. Had the pigs not been stunted by feeding on corn alone during the first period, the difference would in all probability have been much greater.

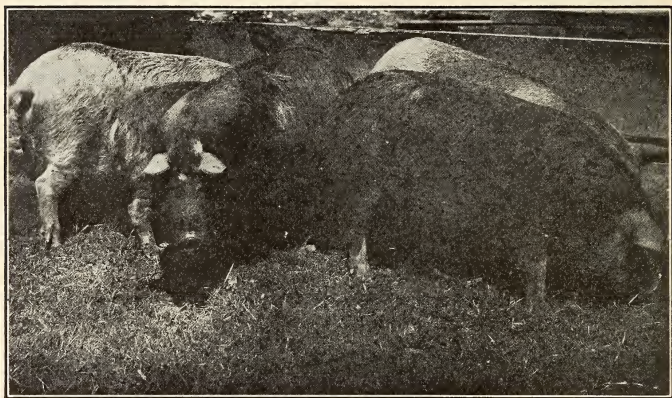
The fact should be considered that five pigs made a total gain of 98 pounds during the second period, whereas six pigs made a gain of 97 pounds during the first period. This gain is favorable to the corn and linseed-meal ration, which was fed under very unfavorable conditions.

Table 1 shows a marked improvement in the gains made by Lot 2 during the first period, when a small amount of fermented cotton-seed meal was fed. While the amount fed per day was less than one-half pound, the gain during the first period was .46 pound per day, with a consumption of 6.67 pounds of feed, representing a cost of 9.33 cents per pound of pork. While this is not in the bounds of profitable production, yet it shows a marked improvement over Lot 1, which was fed on corn alone during the first period.

During the last period Lot 2 made much less satisfactory gains than during the first period. The gain per day was very little more than one-half that made during the first period. This was made at a greater cost of feed consumed, 10.72 pounds per pound gain, which represented an actual cost of 15 cents per pound. While we would naturally expect the gains to be less during the last period, yet this

small gain seems to indicate that there is a limit in feeding the meal, even though no toxic symptoms had developed in the animal before the close of the feeding period.

Lot 3 made very satisfactory gains during the first period, considering the conditions under which the hogs were kept. An average of .62 pound of cotton-seed meal was fed per day during this period, with an average daily gain per head of .63 of a pound. This gain represents the highest average made by any lot during the feeding trials. It required only 5.10 pounds of feed to produce a pound of gain, the gains being made at a cost of 7.14 cents per pound, which was the most economical gain made by any lot during the experiment.



Lot 3.—Fed first period, mixture of 4 parts corn and 1 part cotton-seed meal; and second period, mixture of 7 parts corn and 1 part cotton-seed meal.

The results seem to be clearly in favor of Lot 3 during the first period. Even when compared with the first period of Lot 4, it will be found that the gains made per day were greater and the cost per pound was less.

During the second period there was a marked decrease in the gains made per day by Lot 3. The .25-pound gain made during the second period represents only two-fifths of that made during the first, while the cost per pound was more than doubled.

This serves as a check on the results obtained in Lot 2, apparently corroborating the statement made that if the limitations in cotton-seed meal feeding are exceeded, the gains will be small and unsatisfactory, and even death may result.

With Lot 4 the results during the first period were very similar to those obtained with Lot 3 during the corresponding period. The average daily gains were practically the same, the amount of feed consumed was the same, and the amount of feed used per pound of gain was slightly in favor of the corn and cotton-seed meal ration. As to the cost of gain, there was a difference of 72 cents per 100 pounds in favor of the cotton-seed meal ration.

During the second period the results were reversed. The gains made, the amount of feed consumed per pound of gain, and the cost of gains were clearly in favor of the lot fed corn alone. These results point to the conclusion that ninety days or even less is the extreme limit in cotton-seed meal feeding, under the conditions here described. While we grant that corn would naturally be favorable to large gains during the last stage of fattening, we ordinarily accept the statement that a small amount of nitrogenous material would be helpful when fed in connection with corn. This was not true during the last period with Lot 3. The results were decidedly unfavorable to the meal, when compared with the second period of Lot 4.

For all practical purposes, a ration made up of four parts corn and one part linseed meal is, so far as the results obtained in this experiment are concerned, equal to a ration of corn four parts, cotton-seed meal one part. This is on a basis of efficiency, however, as the linseed meal costs more. Consequently the results would be less satisfactory, financially, when linseed meal was fed. This comparison does not hold good, however, after the first period of feeding, as we find by the results given in Table 1, that the gains made by Lot 4 during the second period were considerably more than the gains made by Lot 3 during the second period, when eating cotton-seed meal. The cost of gain on Lot 4 during the same period was also less than that of Lot 3 during the corresponding period. This again seems to point toward the fact that the limitations of meal feeding have been more or less accurately determined, not only in this experiment, but also by others reporting on the subject.

GAINS BY PERIODS.

The weights of the four lots of hogs at the beginning and ending of the two feeding periods were as follows:

TABLE 2—RATIONS AND GAINS OF THE HOGS BY LOTS AND BY PERIODS.

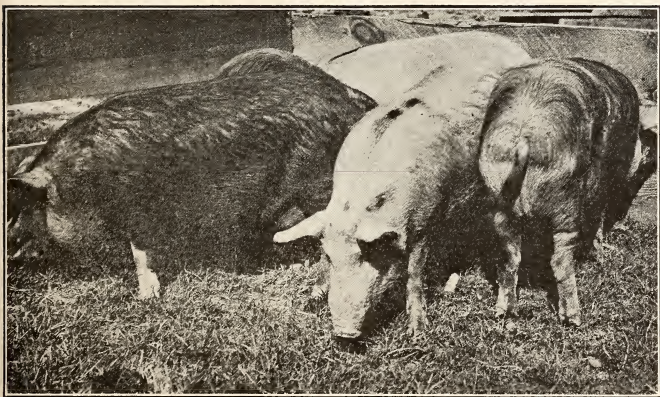
Lot Number.	First Period—90 Days.				Second Period—91 Days.				Total Gain of Lots for Two Periods—Pounds.
	Ration.	Initial Weight, January 29—Pounds.	Final Weight, April 29—Pounds.	Net Gain for Period—Pounds.	Ration.	Initial Weight, April 29—Pounds.	Final Weight, July 29—Pounds.	Net Gain for Period—Pounds.	
1	Corn-----	440	537	97	Corn, 4 parts; linseed meal, 1 part.	487	585	98	195
2	Corn, 7 parts; cotton-seed meal, 1 part.	452	700	248	Corn, 4 parts; cotton-seed meal, 1 part.	610	720	110	358
3	Corn, 4 parts; cotton-seed meal, 1 part.	452	792	340	Corn, 7 parts; cotton-seed meal, 1 part.	707	820	113	453
4	Corn, 4 parts; linseed meal, 1 part.	451	775	324	Corn-----	675	840	165	489

The gain of Lot 1, fed on corn and linseed meal during the second period, was practically the same as the gain made during the first period, when fed on corn alone. Large gains were not expected, however, during the second period, since the general condition of the animals had been greatly impaired by feeding them on the corn ration. The gain per pig was greater, however, since during the first period six pigs were used in each lot, and during the second period only five pigs were used.

This indicates that the addition of linseed meal to the ration during the second period had stimulated greater gains; and the fact that the gains made by Lots 2, 3 and 4 during the second period were materially decreased, as compared with the first period, would add some force to the statement that the limit of profitable cotton-seed meal feeding had been reached after seventy-five to ninety days. This fact could not be taken as conclusive evidence, however, as the addition of linseed meal to the ration of Lot 1 would naturally have an appetizing influence, which would stimulate in making relatively larger gains, and especially would this be so, considering the run-down condition of the pigs in this lot.

On the other hand, we have a factor always to be considered, and that is that the gains made during the last stages of fattening are always less than during the first part of the period, and that generally the cost is more per pound of gain. This, then, accounts partly for the results obtained with Lots 2, 3 and 4. How much to attribute to the detrimental influences of the cotton-seed meal during this particular stage of feeding is a question to be worked out later by extensive experiments.

It seems, however, in the case of Lot 3, that the gain during the second period is so small, absolutely and relatively, when compared with the gain made by Lot 3 during the first period, that the cotton-seed meal, after a certain time, becomes a disturbing factor. In the light of these results, and other evidence at hand, the period during which cotton-seed meal can be fed profitably will depend on the amount of cotton-seed meal fed, the size of the hogs and the general feeding and management. In this particular case seventy-five to ninety days was the maximum limit, and even in the case here mentioned the gains were not profitable. The writer is of the opinion that, under a proper system of management, especially if pasture or some suitable grazing crop is supplied, the gains would have been made profitably, at least, certainly more so than when corn alone or a mixture of corn and linseed meal was fed.



Lot 4.—Fed first period, mixture 4 parts corn and 1 part linseed meal; and second period, corn alone.

Lot 2, during the second period, made a gain of 110 pounds, against 248 pounds during the first three months. Their ration was the same in both periods, except that the proportion of cotton-seed meal given during the second period was greater than during the first. The difference in the gain made by this lot during the first and second periods could be more easily accounted for than in the case of Lot 3, since in the latter the cotton-seed meal was reduced, making a more highly carbonaceous ration, from which we would naturally expect comparatively rapid gains, considering the commonly accepted views on

feeding. There is not enough evidence, however, in the case of Lot 2, to conclude that the cotton-seed meal had any influence in checking the gains, since naturally they would be decreased somewhat.

On the other hand, Lot 3, fed corn and cotton-seed meal in the proportion of four to one during the first period, and seven to one during the second period, made a gain of only 113 pounds during the latter, as against 340 pounds during the former period, which was more than three times as much gain in the first as in the second period. It is possible that this extreme difference might be attributed to the age and condition of the animals during the latter period, yet it does not seem that the decrease would be so great on hogs capable of taking on more flesh and fat, as was the case with this lot.

Lot 4 made a more substantial gain, it being 165 pounds during the second period, as against 324 pounds during the first period. This, however, we would naturally expect, to a certain extent, as corn is a fattening ration, and was given at a time when hogs would make the best use of it. After making a good growth of bone and muscle on feeds such as a combination of corn and linseed meal furnished during the first period, larger gains were made than would have been otherwise.

In case of Lot 4 some strength is given to the claim that cotton-seed meal does influence unfavorably the normal gains after a period of about three months. It is a commonly accepted fact that a small amount of protein feed, such as linseed meal, tankage, etc., added to a corn ration, will make the gains larger and at times more profitable. It would therefore seem that the cotton-seed meal fed to Lot 3 during the second period was given in about the right proportion to induce larger gains. Such was not the case, however, as the meal was a detrimental factor, as Lot 3 made only 113 pounds of gain during the second period, while Lot 4 made 165 pounds, or about one-third more gain than Lot 3. Whether this difference in gain can be attributed to the peculiar physiological effect of the cotton-seed meal is to be determined later. These results seem to point toward such a conclusion.

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

SCUPPERNONG AND OTHER MUSCADINE GRAPES:
ORIGIN AND IMPORTANCE.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
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UNDER THE CONTROL OF THE
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TABLE OF CONTENTS.

	PAGE.
History of the Scuppernong.....	5
Confusion Regarding Early History.....	5
Collecting the Facts.....	7
Original Scuppernong Vine.....	7
Naming the Scuppernong.....	8
Origin of the Word "Scuppernong".....	9
Early Names of the Scuppernong.....	10
Old Vines on Roanoke Island.....	10
Scuppernong a Muscadine Grape.....	10
Importance and Characteristics of the Scuppernong.....	11
Other Important Varieties of <i>Vitis Rotundifolia</i>	13
Varieties with Dark-colored Fruit.....	13
Varieties with Light-colored Fruit.....	17
Varieties with Reddish or Reddish-purple Fruit.....	18
Unimportant Varieties	19
Men Who Popularized the Muscadine Grapes.....	19
Recommendation of Varieties.....	19
Importance of Muscadines in the South.....	19
Muscadines in North Carolina.....	20
Muscadines for Market.....	20
Unfermented Grape Juice.....	20
Self-sterility in Muscadine Grapes.....	21

ORIGIN AND IMPORTANCE OF THE SCUPPERNONG AND OTHER MUSCADINE GRAPES.

BY F. C. REIMER, HORTICULTURIST.

One of the most important things connected with the introduction of a new fruit is a careful study of the conditions which surround the plant in its native home. In the planting of fruits during the past, often too little attention has been given to this matter. The home of a species usually indicates the locality or localities that it is best suited to. It determines in a large measure where that fruit can be grown and where it is likely to give best results. A species is more or less a product of the locality in which it originated, as the conditions prevailing there have in a large measure produced it. By natural selection, nature eliminates those forms not adapted to the environment.

This principle is well illustrated by our native fruits. The grapes of the eastern portion of the United States are far better suited to that section than any of the foreign species. This is also true of our native species of plums, blackberries, dewberries and raspberries.

The same principle applies particularly to varieties. A variety is usually best suited to the particular section in which it originated. The varieties of apples, peaches, pears and plums best suited to the Southern States are those which have originated in the South: for example, the Red June and Bonum apples, the Greensboro and Lady Ingold peaches, which originated in this State, reach their greatest perfection here.

The history and development of most of our important native fruits has been determined and recorded. Bailey and Munson have traced the development of our leading species of grapes, except *Vitis rotundifolia*—the Muscadine grape—on which practically nothing has been done. It is rather difficult to determine why this is true, as it is by far the most important species of grape in the South. The history of the different varieties of the Muscadine grape should be fully determined and preserved. This species has always been a very interesting one to North Carolinians, as it is native to the eastern half of the State, and most of the varieties have originated there.

HISTORY OF THE SCUPPERNONG.

Confusion Regarding Early History.—The following opinions have been offered regarding the origin of the Scuppernong: that it is a foreign variety introduced into this country many years ago; that it is a native of Virginia and was brought to North Carolina by the

early settlers; and that it is a native of North Carolina. Of those who hold to the last belief, some claim Tyrrell County and others Roanoke Island as its original home.



Fig. 1.—Characteristic Old Scuppernon Trunk.
(Circumference seven feet six inches.)

Although much has been written regarding this variety during the last half century, no one has indicated how and when the name "Scuppernon" was assigned to it. It is believed by some that this honor belongs to the North Carolina Indians; by others, that it belongs to the early white settlers. Some maintain that the name was taken from Scuppernon River, and others that Scuppernon River was named for the grape.

The writer determined long ago to clear up this confusion. The history has been determined, and the facts, we believe, are of importance to the grape industry of this State and the South, and to horticulture in general.

Collecting the Facts.—It was first necessary to review all of the old books, magazines and periodicals on Southern horticulture and agriculture, especially those on grapes; but very little information could be found regarding the origin of this grape. The most important facts were obtained from files of the old newspapers of the State, especially those published during the early part of the nineteenth century. Information of considerable value was also found in some of the old State and family records.

The writer made an extensive trip to all of the old grape sections in the eastern part of the State. All of the old vines of which any record could be found were examined and carefully measured, and their history was determined as fully as possible. Interviews were held with the descendants of the earliest grape growers; and in this way facts were obtained that throw much light on the subject.

The Original Scuppernong Vine.—It seems to be impossible to locate with absolute certainty the original Scuppernong vine, as no authentic records of the original vine can be found. This, of course, is perfectly natural, as little or no interest was taken in recording the history of any fruits at that early date. The writer feels certain that the original vine was found in northeastern North Carolina, and probably in Tyrrell County.

The earliest authentic record that we have of this grape comes from New Bern, North Carolina. According to a letter by Judge Gaston, dated June 4, 1838, his old neighbor, a Mr. Hickman, brought a young plant of this grape from Tyrrell County, about 1760, and planted it near New Bern, where it became generally known as the Hickman grape.

The most reliable information to be obtained regarding the finding of the original plant of this grape was supplied by the great-granddaughter of the supposed discoverer, Isaac Alexander. The history which has been handed down verbally from generation to generation in that family is, in substance, as follows:

Isaac Alexander went from Mecklenburg to Tyrrell County about the middle of the eighteenth century to take possession of a tract of land granted to him by the English king. In exploring the region, he found not far from Albemarle Sound a wild grapevine bearing large, luscious white grapes. It is said that this was the original vine which many years later was named Scuppernong.

As that region became settled, the vine was rapidly propagated, and, according to several authentic articles, nearly every home in the locality had near it at least one of these vines at the opening of the nineteenth century. It was soon discovered that this grape made ex-

cellent wine, and as early as 1809 extensive plantings of it could be found in the vicinity of Lake Scuppernong. The grape was commonly spoken of as the White Grape.

On December 21, 1809, the following letter, written by Governor Smith, appeared in *The Star*, a newspaper then published at Raleigh, North Carolina:

"Description of an extraordinary and excellent kind of grape produced in the northeastern part of North Carolina, but not generally known even in that State.

"The grape is large and sweet, of the species of the Fox grape, but white; has been cultivated a number of years in the neighborhood of Lake Phelps, but it is not clearly understood whence it originated. It is supposed to be a native. There are few settlers about the lake but what have a grapevine, which is generally planted at the root of some large mulberry, beech or oak tree, or trained along an arbor of poles lying on forks high enough for a person to walk under and gather grapes conveniently. The vines are never pruned, but suffered to run in a rude state, and many people have vines that will make them a barrel of wine.

"The wine is made by gathering the ripe grapes, picking out all those which are green or bruised, and squeezing the juice into a cider press as soon as they are gathered (for if they lie from one day to another the juice will sour and the wine will always have that taste), when it is put in a clean barrel. To every three quarts of grape juice one quart of brandy is added. After three or four days the wine is raked off till it is clear, and when it gets age is much approved of.

"The process above mentioned is that now followed, but as there are several gentlemen of information sending to the people in that neighborhood to make wine for them, a better process may be discovered. Some have tried fermentation, but it did not answer."

Naming the Scuppernong.—On January 31, 1811, *The Star* published under the heading, "North Carolina Wine from Native Grapes," part of a report made by James Blount, of Scuppernong, North Carolina, who had been appointed to take the census of Washington County. In this report he states that Washington County produced thirteen hundred and sixty-eight gallons of wine from native grapes during 1810. Mr. Blount in his report further says:

"Having taken an account of the wine in my division, I think it my duty to state the result of my inquiries on this small but very interesting branch of our infant manufactures.

"The large white grape from which most of this wine is made is said to be a native of America, and probably of North Carolina, as no person can tell its origin; and I feel inclined to join in this opinion, having about three years ago found a vine with ripe fruit on it of this kind in the woods, where it is very improbable it could have been planted. I am told the grape from the seed will be purple and larger than from the cuttings of the vine, though not so sweet. These vines thrive well on various kinds of soil, but delight most in that which is loose and sandy, and if care is taken to manure them for two or three years it will afterwards only be necessary to keep the weeds clear, prune and scaffold them; and one vine is worth more than fifty apple trees."

The editors of *The Star* add the following comments to Mr. Blount's report:

"Our readers will recollect a communication on this singular and excellent species of grape (which for the sake of distinction, until we are better instructed, we shall denominate the Scuppernong Grape) in the 239th page of our first volume. That communication excited considerable interest and procured for us another favour of the same kind from Mr. Cooper, which will be seen in page 38 of our second volume."

The grape was named "Scuppernong" because of the numerous plantings of this variety along the Scuppernong River at that time. The name was also given as a compliment to James Blount, who lived near that river and whose excellent articles on this grape attracted much attention at that time.

At that time, Dr. Calvin Jones and Thomas Henderson were editors of *The Star*. The honor, then, of naming this grape belongs to the editors of a Raleigh (North Carolina) newspaper. It is very probable that it should properly be given to Dr. Calvin Jones, who was a noted naturalist, and edited the agricultural part of *The Star*.

The writer feels certain that this is the first time that this grape was designated as *Scuppernong*. He has not been able to find this name used in any of the earlier writings; and Blount, in his report two years previous to that date, speaks of it as "the large White Grape." The following extracts from a letter written by James Saunders of Chowan County, North Carolina, to the editors of *The Star* and published in that paper April 17, 1812, under the title "Scuppernong Grapes and Wine," also lead to the same conclusion:

"Your publishing with such lively interest the properties of that excellent fruit you have named the 'Scuppernong Grape,' while it appeared you were yourselves quite a stranger to it, has induced me to endeavor to prepare and convey to you, this fall, a few slips of that valuable and most luxurious article.

"The usual or common name given those grapes here is the 'White Fox.' So far as my information goes, I think it is most probably a native of Roanoke Island, near Roanoke Inlet, where some have conjectured Sir Walter Raleigh either found or left them. However, I have heard no person object to the name you have given, nor do I expect that any will, for the neighborhood about Scuppernong for several years has abounded with them, and for some time past the inhabitants have been turning them to good account, and, with the help of the encouraging *Star*, this branch of economy and industry may be brought to high perfection."

Origin of the Word Scuppernong.—The word Scuppernong is a corruption of the Indian word *ascuponung*, meaning place of the ascupo, ascopo, or askopo. The word *ascopo* was the Algonquin Indian name for the Sweet Bay (*Magnolia glauca*). This tree is very abundant along the Scuppernong River.

On the old maps of the State we find that the word *ascuponung* was gradually changed until it has become badly corrupted. Eman Bowen gives it as *cuscoponung* in 1752. On a map by Joshua Fry, published a little later, it is given as *cusponung*. In 1770 John Collet changes it to *Scuponung*. In 1771 James Cook again changes it to *Scuponing*. Some time between 1775 and 1800 it was finally changed to *Scuppernong*.

Early Names of the Scuppernong.—During the early history of this grape and before the name Scuppernong became generally used, it was known by different names in different localities. The original name was the White Grape. Around New Bern, North Carolina, it was known as the Hickman grape, having been named for a Mr. Hickman who introduced it into that locality. It has also been designated as the Roanoke Grape, White Scuppernong, and Green Scuppernong.

Old Vines on Roanoke Island.

It is often stated that the original Scuppernong vine is still growing on Roanoke Island, where it was first found. The writer feels quite certain that this is a mistake. He examined these vines on Roanoke Island carefully and found that there are five vines of about equal age that undoubtedly were planted there, as they stand in two straight rows. It is true that these vines are very old, but certainly not as old as some in Tyrrell County.

It is not definitely known who carried the young plants of this grape from Tyrrell County to Roanoke Island, but as there was considerable traveling and trading between this island and the mainland along Albemarle Sound, it is readily understood how the vine or vines could have been carried to the island.

It is stated by some that the vines were carried from Tyrrell County to Roanoke Island by Ann Ashbee. This may be possible, as Ann Ashbee in 1799 married Maurice Baum, who in 1797 had purchased the property on Roanoke Island on which the old vines now stand. Certain records seem to indicate, however, that these vines were planted at an earlier date.

SCUPPERNONG A MUSCADINE.

The Scuppernong is a variety of the Muscadine grape, *Vitis rotundifolia*, which grows wild abundantly all through the eastern part of the State. Some writers dispute this, but it is difficult to understand how anyone who has seen the Scuppernong and the wild Muscadine vines can conclude that the Scuppernong is not a native grape. The variety has every characteristic of that species. The trunk, vines, aerial roots, tendrils, leaves, and flowers are characteristic of this species. It is true that the fruit of the Scuppernong is light or whitish in color, while that of the Muscadine is usually dark-purple or black. Still we know that the black Fox grape, *Vitis labrusca*, often produces white-fruited seedlings. Many species normally producing black fruit now and then produce forms which yield white fruit.

Furthermore, the writer has seen a wild Muscadine vine bearing white fruit. (See Fig. 2.) It was found growing wild in the woods on Roanoke Island. He has also seen two white-fruited Muscadines

now growing on the farm of J. A. Swain, Columbia, North Carolina, which were found in the woods near Columbia, by his father, Timothy Swain. Still further proof is that most of the seedlings of the Scuppernong have purple or black fruit and are as typical Muscadines as can be found anywhere. Then, too, the Pee Dee grape is a white-fruited Muscadine that was originally found growing wild in South Carolina.



Fig. 2.—Wild White Muscadine.

IMPORTANCE AND CHARACTERISTICS OF THE SCUPPERNONG.

The Scuppernong was the first American or native grape to be brought into cultivation. It has always been the most important variety of this species and has been more generally planted than all of the other muscadines combined. It became popular as soon as introduced because of its great hardiness—growing and bearing well under neglect, and producing an excellent table grape and wine.

The vine is a vigorous grower and attains immense size, as is seen by Fig. 1, which shows a Tyrrell County vine measuring seven feet six inches around the trunk. It is notably healthy, not being seriously affected by either insects or diseases, and is generally a regular and heavy bearer when growing on suitable soils. It is long-lived; some of the vines now bearing good crops are more than a hundred years

old. One marked peculiarity of the vine is the splitting-up of the main trunk into several divisions, when it becomes very old; also the production of aerial roots when trained on arbors. The vine can be quite readily distinguished from the dark-fruited varieties by the light-colored ends and nodes of the young shoots, the whitish or light-green tendrils and new growths of the aerial roots.

The flowers are perfect, and appear during June in North Carolina. Flowers (and fruit) are borne on the new wood, and not on the old wood, as some of our popular writers have stated. The clusters vary



Fig. 3.—Scuppernong.

considerably in size, containing from one to twenty-five berries, usually being much larger on sandy than on clay soils. The berries are round, large, often becoming an inch in diameter; the color varies from pale green to golden russet; skin thick but tender for a Muscadine. The pulp is tender, juicy, with a sweet, rich, characteristic aromatic flavor; and the quality is very good, especially when grown on sandy soils. The chief defects of this grape are the readiness with which the berries shatter from the cluster when fully ripe, and the

irregularity of ripening of the berries even on the same cluster. The ripening period covers the entire month of September in North Carolina.

The Scuppernong is distinctly a wine grape. It makes a rich, light-colored wine, which has no superior among sweet wines. The large plantings in this State, some of which cover from one hundred to six hundred acres, were made primarily for wine production. A bushel of fruit will produce from three to four gallons of wine.

It is also a good table grape when used soon after gathering; but as the skin is often broken, in picking, where the stem is attached, the fruit sours readily during warm weather. It cannot be shipped successfully except when used for making wine.

This is distinctly a grape for sandy soils, and should never be planted extensively on heavy clay. It is more productive, and the clusters and berries are larger, more juicy and of better quality on sandy or sandy-loam soils than on clay soils.

OTHER IMPORTANT VARIETIES OF VITIS ROTUNDIFOLIA.

Varieties With Dark-colored Fruit.

Flowers.—This excellent late grape comes from Robeson County, North Carolina. It was discovered early in the nineteenth century by William Flowers, about sixteen miles south of Lumberton, in Flowers Swamp. In 1816, Giles Williams visited the parent vine for the purpose of obtaining cuttings. He states that the vine then had the appearance of being about ten or twelve years old. As the fruit of this variety ripens very late and makes an excellent red wine, it soon became the leading black grape in the South for wine making. This is the most popular late variety of this species, the fruit being at its best the latter part of October and during November. The vine is unusually vigorous and is a very heavy bearer. The clusters are large and contain from ten to twenty-five berries, which are large, slightly oblong, purple to black in color, and cling to the cluster unusually well, being equal to any of the bunch grapes in this respect. This is due to the stem being attached on the inside of the fruit, into which the fibro-vascular bundles extend from one-eighth to one-fourth of an inch. This is an important characteristic, as it enables the fruit to be shipped long distances without the shattering of the berries which usually occurs with most of the varieties of this species. The pulp is rather hard and harsh and the flavor is inferior to that of most of the other varieties. For table purposes it has little to recommend it except its late ripening season. For wine making it has no superior; and it will probably make excellent unfermented grape juice. The large clusters and the clinging quality of its berries seem to commend it for breeding work.

Flowers Improved.—This variety was found by J. M. Shipman, about 1869, near Red Hill Swamp, nine miles north of Whiteville, North Carolina. As it has been only locally advertised, it is not generally grown. The variety has a great deal to recommend it, being superior in some respects to its parent, the Flowers. The vine is more vigorous and more productive; the fruit is similar to the Flowers, but the clusters are larger and the berries more oblong and cling tenaciously to the stem, which is attached internally. It ripens as late as its parent, and for wine making and breeding work seems to be equally promising.



Fig. 4.—James.

James.—This is a native of Pitt County, North Carolina. It was found by B. M. James, in 1866, about three miles south of Parmele, on the Weldon and Kinston Railway. Mr. James was attracted to the grape because of the very large size of the individual berries, and by the fact that they remained on the vines in perfect condition until very late in the season. He propagated the variety and sold it quite extensively. At present it is probably the most widely planted and most popular black grape of this species. The vine is very vigorous and productive; the clusters are of medium size and contain from five to fifteen berries, which are bluish-black

in color and are the largest of any in this group, often measuring an inch and a quarter in diameter. The skin is thin, the pulp tender and juicy, and the quality very good. The chief defect of this variety is the readiness with which the berries shatter from the cluster as soon as ripe. It is much better suited to clay soils than the Scuppernong and is probably the best general-purpose variety of the group.

Hopkins.—This grape was originated near Wilmington, North Carolina, about 1845, by John Hopkins, an English gardener, who came to that place in 1840. It is said to be a cross between a wild

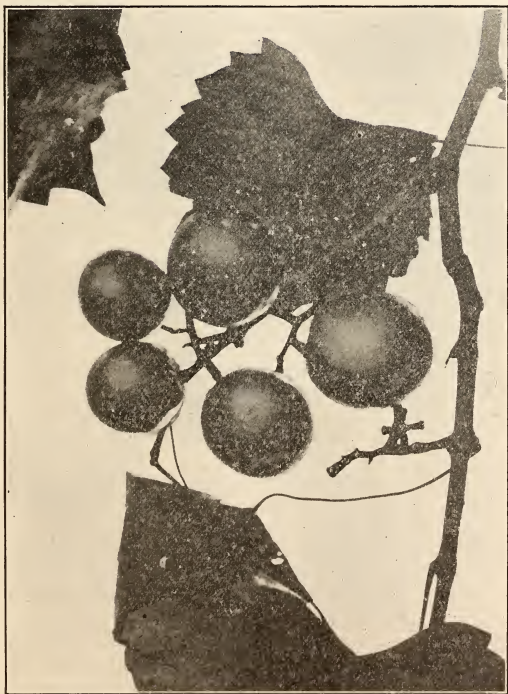


Fig. 5.—Memory.

(Clusters usually larger than that illustrated.)

black grape and the Scuppernong. It is not known at present what the wild black grape was, but it is very probable that it was a muscadine. Others maintain that this variety is simply a superior seedling of the Scuppernong. As the fruit of this grape ripens earlier than

that of any others belonging to this species, and as it is of excellent quality, it is rather strange that this grape has not been more widely grown. The vine is exceedingly vigorous and healthy, the clusters and black berries are large, the pulp is tender, and the flavor unsurpassed. This variety is a valuable member of this group, as it lengthens the ripening season nearly a month, beginning early in August. It should be found in every home vineyard.

Memory.—The Memory was introduced, in 1868, by the late T. S. Memory, of Whiteville, North Carolina. Some of its characteristics and the fact that it was found in his vineyard among some Thomas grapevines indicate that it is a seedling of the Thomas. The grape proved to be an excellent one, and Mr. Memory named it for himself. The vine is probably the most vigorous grower of this group. The fruit ripens in September; the clusters are of good size, and the berries cling to the clusters until they become shriveled. The berries are very large, oval to oblong in shape, and jet-black in color. The pulp is juicy, very tender, exceedingly sweet and delicious. This variety has not become as widely distributed as its good qualities merit. It should be in every home vineyard, and for local market it has no superior in this species.

Mish.—This variety was found by William Henry Mish, about 1846, at Swann Point, on the Pamlico River, about six miles east of Washington, North Carolina. He found it growing in the sand twelve or fifteen feet from the river. The variety was named for the finder and introduced by him shortly after being discovered. It soon attracted much attention and was widely planted throughout the South. Extensive plantings of it can be found at present around Washington, North Carolina. The vines are vigorous and very productive. The clusters are large; the berries medium in size, round, purplish in color, and adhere well to the clusters. The pulp is tender, juicy, very sweet and of exceptionally fine quality. This variety should be planted in every vineyard, because of its fine flavor and good shipping qualities.

Sugar.—This is another variety introduced by the veteran grape grower, T. S. Memory, of Whiteville, North Carolina. It was found by him at Whiteville, between 1865 and 1870. The variety has never been widely grown, and at present the writer is able to locate only a few vines of it. It does not possess any special characteristics to commend it.

Tenderpulp.—Tenderpulp originated in the vineyard of D. P. High, at Whiteville, North Carolina, about 1868. It is very likely a seedling of the Flowers. Although the pulp is very tender, it is low in sugar content, and of poor quality. It has nothing to commend it except its exceedingly tender flesh, and its productiveness. Because of its poor quality, it has never become very popular.

Varieties With Light-colored Fruit.

Pee Dee.—The Pee Dee was discovered by some negroes on Dr. H. Williamson's place at Darlington Court House, South Carolina, just prior to the Civil War. During the war, it was brought to Dr. Williamson's attention. It was undoubtedly an accidental seedling, as it was found growing over a fence where everything seemed

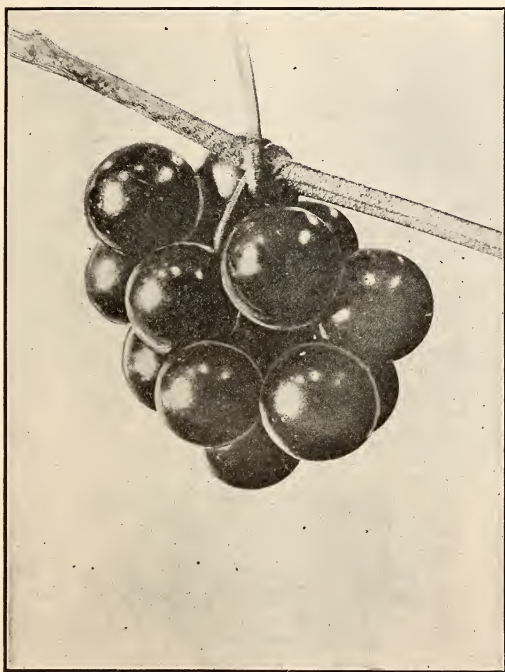


Fig. 6.—Mish.

to indicate that it had not been planted. This variety never became very popular or widely distributed and at present is seldom met with. It is an interesting variety because the color of the berries is similar to that of the Scuppernong. It has nothing to commend it over that variety except its late ripening habit. For wine and jelly it is excellent.

Varieties With Reddish or Reddish-purple Fruit.

Thomas.—This excellent variety was found about 1845, in the woods four miles from Marion, South Carolina, by Drewry Thomas, and takes its name from Mr. Thomas, who introduced it. The variety at once became popular because of its delicious sweetness, and has been widely planted. It is unique as a muscadine because it is the only variety of the species that has reddish or reddish-purple fruit. The vine is not a vigorous grower, but is very productive.



Fig. 7.—Thomas.

The clusters are large, and the berries shatter readily when fully ripe. The fruit ripens early, and the berries are small, round, reddish, with a thin, tender skin. The pulp is tender, juicy, sweet, and exceptionally rich. As a table grape the quality could hardly be im-

proved on. The only other variety that equals it in this respect is the Memory. It should be planted in every vineyard, and if but one variety is to be planted for home use, Thomas is the variety.

Unimportant Varieties.

There are several varieties of this species grown only locally, and it is quite probable that they will never be widely grown, or become of any special importance. Such varieties are Beula, Westbrook, Jeter, and Seedlin.

MEN WHO POPULARIZED THE MUSCADINE GRAPES.

Since North Carolina is responsible for the introduction of most of the varieties of this species, it is only just to mention the names of the men who were largely responsible for their introduction. These men were Thomas Blount, of Washington County; Hickman, of Craven County; Calvin Jones, of Wake County; Sidney Weller, of Halifax County; Henry Mish, of Beaufort County; T. S. Memory and D. P. High, of Columbus County; L. Froelich, of Duplin County; and J. Van Buren, of Georgia.

RECOMMENDATION OF VARIETIES.

- a. For home use:
Hopkins, Thomas, Scuppernong, Mish, Memory and Flowers Improved.
- b. For wine:
Scuppernong, James, Flowers and Flowers Improved.
- c. For unfermented grape juice:
James, Mish, Memory and Flowers.
- d. For general market:
Mish, Memory and Flowers Improved.

IMPORTANCE OF MUSCADINE GRAPES IN THE SOUTH.

The varieties of this species have always been the most important grapes in the warmer sections of the South. They are especially well adapted to the climatic and soil conditions of the Coastal Plain region from southeastern Virginia to Texas. The vines grow luxuriantly, and as the bloom appears very late, they are regular bearers. The fruit is practically free from fungous diseases and is very rarely attacked by insects. Most of the muscadines ripen their fruit comparatively late in the season, after most other grapes are gone, and at the best season for wine making. Most other grapes grown in the South are quite subject to rot and insect injury, and the vines are short-lived.

MUSCADINES IN NORTH CAROLINA.

The Muscadine grapes are not equally well adapted to all parts of the State. They reach their greatest perfection in the Coastal Plain section. This, of course, is quite natural, as it is the home of most of these varieties. The climatic and soil conditions there are admirably suited to them.

They also do well in the Sand Hill region of the State. Even on the poor, white, dry sandy soils where few other plants thrive, these grapes reach a high degree of development.

They will grow quite well in the Lower Piedmont section, and especially on sandy soil, but the clusters are much smaller and the flavor inferior to those grown in the Coastal section. This is especially true on clay soils. For commercial purposes they should not be planted in this section.

Attempts to grow them in the Mountain and Upper Piedmont sections have usually resulted in failure. While the vines grow well in the Upper Piedmont, they very seldom bear fruit. They should not to be planted extensively at an elevation greater than six hundred to seven hundred feet.

MUSCADINES FOR MARKET.

These grapes are especially well suited to the family vineyard and for wine making, and may be marketed with some degree of success. Considerable objection has been raised against them for market purposes because of the small size of the clusters, but this objection does not always hold, as some of the varieties bear as many as fifteen to twenty-five berries to the cluster. Other things being equal, the clusters are much larger when grown on sandy soils than on clay soils. With some of the varieties the fruit shatters readily from the cluster as soon as ripe; with others the berries cling as tenaciously to the cluster as with any other variety of grapes.

UNFERMENTED GRAPE JUICE.

The question is often asked whether these grapes can be used successfully for making unfermented grape juice. Careful experiments by one of the largest wine manufacturers in the South show that some varieties of this species, especially the dark-fruited varieties, are well suited for this purpose. The writer knows of no reason why this should not become an important industry in the South. Although the Scuppernong does not seem to be so well suited for this purpose as the dark-fruited varieties, yet carefully conducted tests have shown that it may be successfully used.

SELF-STERILITY IN MUSCADINE GRAPES.

One of the most important questions connected with the growing of Muscadine grapes is whether or not they are self-sterile. At present this cannot be definitely answered, at least for all varieties; and more and better work will have to be done to determine this point. Certainly the same answer may not apply to the group as a whole. It is possible that some varieties will prove to be self-fertile and others self-sterile. Undoubtedly soil and climatic conditions have some influence on fertility in this group. Some of the varieties, notably the Scuppernong, appear to be more nearly self-sterile on the clay soils in the Piedmont section than on the sandy soils in the Coastal section. Some Scuppernong vines appear to be self-fertile and others self-sterile under apparently similar conditions.

The writer's work, while confined to only one season and one section of the State, gave decided results. A large number of flower clusters of the Scuppernong and Flowers were covered with paper bags before the flowers opened, and not a single fruit was produced. On the same Scuppernong vines other flower clusters were covered similarly, but later when the stigmas became receptive a flower cluster from a *male* vine was tied to each of these Scuppernong flower clusters. Three-fifths of these matured normal-size clusters of fruit.

BULLETIN 202

MAY, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

**COLLEGE OF AGRICULTURE AND
MECHANIC ARTS**

WEST RALEIGH

**MANUFACTURE AND MARKETING OF COTTAGE
CHEESE, SKIMMILK-BUTTERMILK
AND ICE-CREAM.**

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
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UNDER THE CONTROL OF THE
TRUSTEES OF THE A. AND M. COLLEGE.

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Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
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TABLE OF CONTENTS.

	PAGE.
Introduction	5
Preparation of Pure Cultures of Lactic Acid Bacteria.....	5
Making Cottage Cheese.....	6
Souring the Skimmilk.....	6
Heating the Curd.....	7
Draining the Curd.....	7
Grinding the Curd.....	8
Yield and Selling Price of Cheese.....	8
Making Skimmilk-Buttermilk	8
Souring the Skimmilk.....	8
Churning	9
Cooling	9
Straining and Bottling.....	9
Selling Price	9
Marketing Skimmilk-Buttermilk and Cottage Cheese.....	9
Selling Direct to Consumers.....	10
Food Value of Cottage Cheese and Skimmilk-Buttermilk.....	10
Serving Cottage Cheese.....	11
Marketing Ice-cream	11

MANUFACTURE AND MARKETING OF COTTAGE CHEESE, SKIMMILK-BUTTERMILK AND ICE-CREAM.

BY JOHN MICHELS, DAIRY HUSBANDMAN.

In making cottage cheese and buttermilk the first and most important essential is good flavor. Next in importance is uniformity of product. Both of these essentials can be obtained with certainty only by the use of pure cultures of lactic acid bacteria in souring the skimmilk.

The natural souring of milk is due to lactic acid bacteria, which act upon the milk sugar, changing a portion of it into lactic acid. Milk always contains these souring bacteria, but, as a rule, there are present also various other types which produce undesirable flavors. To suppress the undesirable types of bacteria, it is necessary to reinforce the lactic acid organisms by adding large quantities of them in pure form, that is, unmixed with other classes of bacteria. Commonly, such pure cultures of lactic acid bacteria are known as starters.

PREPARATION OF PURE CULTURES OF LACTIC ACID BACTERIA.

The cultures containing the lactic acid ferment are prepared commercially, and small samples, either in dry or liquid form, can be obtained from manufacturers at about seventy-five cents per bottle. The bottle thus obtained is emptied into a quart of pasteurized skimmilk, that is, skimmilk which has been kept at a temperature of about 170° F. for thirty minutes and then quickly cooled to about 70° F. As soon as the quart of skimmilk has thickened, which usually requires about twenty-four hours, it is ready for use.

In the process of heating, all of the active bacteria in the skimmilk have been destroyed, thus leaving a clean field for the development of the lactic acid bacteria added to it from the bottle.

The method of using the lactic acid bacteria is similar to the use of yeast in breadmaking. The original germs obtained from the manufacturer may be propagated for weeks by daily transferring a small amount of the thickened skimmilk to newly pasteurized skimmilk. As a rule, one pound of the thickened skimmilk will sour thirty to forty pounds of sweet pasteurized skimmilk in twenty-four hours at a temperature of 70° F.

Parenthetically, it may be stated that pure cultures of lactic acid bacteria (starters) are also frequently used in souring cream for buttermaking. Indeed, the highest quality of butter is not possible without their use.

MAKING COTTAGE CHEESE.

Hitherto no definite method has been employed in the making of cottage cheese, which, no doubt, is largely due to the fact that its manufacture has been almost entirely confined to the home. The method in common use consists essentially in placing curdled milk, either heated or unheated, in a linen or cotton cloth bag which is hung up in some convenient place to allow the curd to drain.

Where cheese is to be made on a commercial scale, this method has not been found satisfactory. After much experimentation we have

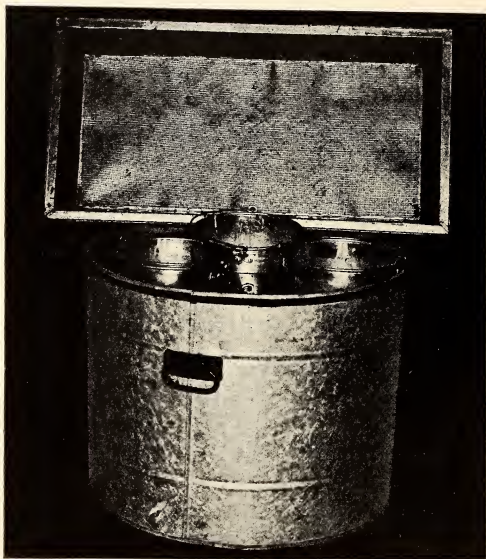


FIG. 1.—Strainer and Shotgun Cans in Water Tank.

succeeded in developing a method which has proven perfectly satisfactory in making cheese for city trade, and which it is felt can confidently be recommended for use by dairymen in general. The successive steps in this process are described in the paragraphs following.

Souring the Skimmilk.—Where from ten to twenty pounds of cheese are to be made at one time, the skimmilk is most satisfactorily soured in four to eight gallon shotgun cans which have a uniform

diameter of from eight to ten inches. Enough pure culture of lactic acid ferment is added to sour the skimmilk in about three hours at a temperature of 100° F. As a rule, one gallon of culture to every four gallons of sweet skimmilk will accomplish the souring in the given time.

The culture should be vigorously stirred and then thoroughly mixed with the skimmilk. As soon as this has been done the cans containing the mixture are placed in a tank of water, as shown in Fig. 1. In heating the skimmilk to 100° F. the water in the tank should never exceed 110° F. The high temperature employed in souring the skimmilk has several advantages: (1) it hastens the souring process; (2) it causes the skimmilk to curdle with less acid, thus making a milder cheese; and (3) the curd may be stirred as soon as curdled without danger of diminishing the yield.

Where large quantities of cheese are to be made, the skimmilk



FIG. 2.—Curd in Strainer after pressing, and Curd Grinder.

should be soured in a common cream vat with an open end, which is usually used for adding ice to the water underneath. In the manufacture of cottage cheese, this open end is necessary in order to observe the temperature of the water used in heating the milk and curd.

Heating the Curd.—As soon as the skimmilk has thoroughly curdled, the curd should be raised to a temperature of 104° F. by heating the water surrounding the curd to about 115° F., and care should be taken never to heat it above 120° F. During the heating the curd should be constantly stirred with a stirrer consisting of a four-inch heavy tin disc attached to an iron rod. Where a cream vat is used, the stirring is done by hand. When the curd has reached a temperature of 104° F. the water surrounding it should be removed and the stirring continued for ten minutes more, after which it is ready to drain.

Draining the Curd.—This is best accomplished in a tin strainer with perforated sides and bottom like that shown in Figs. 1 and 2. The strainer should be of ample size to hold conveniently all the curd,

to expedite drainage. A piece of cheese cloth should be spread over the strainer before receiving the curd. The latter must be hand-stirred as soon as it reaches the strainer, but the stirring should be done very carefully at the start to avoid loss by mashing the particles. Continue the operation until the curd is firm enough to prevent the particles from sticking together, which usually requires about five minutes. When proper firmness is reached, the curd is wrapped in the cloth strainer and squeezed with the hands until most of the whey has been removed. This operation requires only a few minutes, and care must be taken not to press the curd too hard. After pressing, the curd appears in a roll like that shown in Fig. 2.

Grinding the Curd.—Immediately after pressing, the curd is run through an ordinary meat grinder (see Fig. 2). The machine should be set for coarse grinding and should be large enough to enable one to complete the operation in a few minutes. *

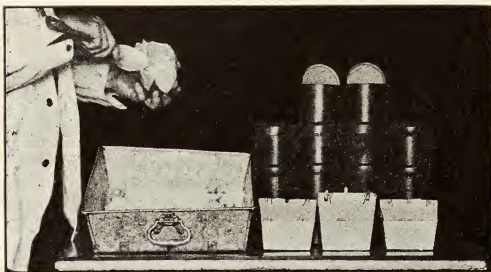


FIG. 3.—Cottage Cheese Packages and method of filling them.

The cheese is then put into packages by means of a large spoon, in the manner shown in Fig. 3. One-pound packages appear to be the most satisfactory for the average trade.

Yield and Selling Price of Cheese.—On an average it requires 7.1 pounds of skim milk to make one pound of cottage cheese. The cheese was furnished grocers at ten cents per pound and was retailed by them at fifteen cents. We were able to dispose of twenty pounds per day at this price on the local market, a city in which the cheese had never been handled before.

MAKING SKIMMILK-BUTTERMILK.

Souring the Skimmilk.—As soon as the skimmilk leaves the separator, whole milk is added to it at the rate of one gallon to twenty gallons of skimmilk. This gives the mixture a fat content which ap-

*After grinding the curd, it is soaked with sweet whole milk, using about one and one-half quarts for every ten gallons of skimmilk used.

proximates that of natural buttermilk. A large quantity of pure culture of lactic acid bacteria (starter) is next added and the temperature brought to 70° F. Enough culture is added to curdle the skimmilk in about six hours at the temperature mentioned. When a temperature above 70° F. is employed, there is a tendency for the skimmilk to "whey off" after it has curdled.

Churning.—When thoroughly curdled, the skimmilk is placed in a churn and churned for forty minutes in the same way that cream is in making butter. The churning process thoroughly breaks up the curd clots, resulting in a smooth, thick liquid which cannot be distinguished from ordinary good buttermilk.

Cooling.—Immediately after the buttermilk leaves the churn, the temperature should be reduced below 50° F. to prevent further development of acidity. Ordinary milk and cream coolers with enlarged holes in the distributing receptacle will answer very satisfactorily.

Straining and Bottling.—After cooling, the buttermilk should be run through a strainer consisting of one thickness of cheese cloth to remove any unbroken curd clots. As soon as strained the buttermilk is bottled or put in tin cans holding from one to five gallons, after which it is placed in the refrigerator, where it should be held at a temperature of 40° to 45° F. until ready for delivery.

Selling Price.—The buttermilk made by us was sold to drug stores, lunch counters and hotels at five cents per quart in quart bottles and at fifteen cents per gallon in tin cans holding from one to five gallons. On an average, fifteen gallons were readily sold daily on the local market.

In the larger cities, buttermilk sells at a considerably higher price than given above. Thus, for example, the writer found that buttermilk during the past summer was furnished in bulk in Norfolk at from twenty-five to thirty cents per gallon. Considering both its food and tonic properties, buttermilk may be considered cheap at ten cents per quart.

MARKETING SKIMMILK-BUTTERMILK AND COTTAGE CHEESE.

What is said here with reference to this subject is a narration of our own experience in introducing these products in a city where they had never been used before.

In trying to sell skimmilk-buttermilk, it is necessary, in the first place, to explain that this product when made as described above is almost identical with the highest grade of natural buttermilk both in composition and physical properties, and therefore in palatability and wholesomeness. Indeed, it is not thought possible under average conditions to secure natural buttermilk of as uniform a quality or of as fine a flavor as can be obtained from skimmilk. When these facts are

explained to dealers and consumers, any prejudice which might exist against this artificial product will gradually disappear.

The dealers in buttermilk were each furnished with an attractive display sign calling attention to the fact that the product was for sale at the particular place. Buttermilk is not commonly found at soda fountains, and unless conspicuous signs are posted at these places the public will not call for it. We believe that four-fifths of the buttermilk sold by us was due to these signs. Attention was also called to the product through the local press.

A similar arrangement was made with grocers in handling the cottage cheese. With small outlay for advertising in a city where these products had never been handled, we were soon able to dispose of over one hundred dollars worth per month.

Dealers should keep the cottage cheese and buttermilk in refrigerators, and neither of the products should be sold when more than two days old; the fresher the product the better.

SELLING DIRECT TO CONSUMERS.

It is recommended that dairymen supplying milk and cream to cities undertake the manufacture of cottage cheese and skimmilk-buttermilk, and to sell these products direct to consumers. This would insure getting the products fresh to the consumer every day, and would not entail any delivery charges, since the products would be delivered at the same time as the milk and cream. Furthermore, the profits of the middleman would be added to those of the dairymen. It is confidently believed that this would be the means of increasing the returns from dairies from ten to fifty per cent. The buttermilk could readily be disposed of at five cents per quart and the cottage cheese at from ten to fifteen cents per pound. Dairymen who could produce more of these products than could be disposed of to consumers direct could also supply them to the various local dealers in dairy products.

FOOD VALUE OF COTTAGE CHEESE AND SKIMMILK-BUTTERMILK.

These, when made as herein described, not only have a high food value, but possess tonic or medicinal qualities which are especially beneficial during warm weather. The food value of cottage cheese is approximately the same as that of beefsteak, pound for pound; and as for buttermilk, two quarts of this may be considered fully equal to one pound of beefsteak. Thus it will be seen that cottage cheese at fifteen cents per pound and buttermilk at seven cents per quart are no more expensive than steak at fifteen cents per pound.

SERVING COTTAGE CHEESE.

When the cheese is made according to the method given above, it may be served without any further treatment. Its palatability, however, may be improved by the addition of cream. Additional salt and some pepper is also preferred by some. Others prefer adding sugar or syrup. Caraway and sage are also sometimes used to flavor the cheese.

MARKETING ICE-CREAM.

Hardly any attempt has yet been made by cream producers living within driving distance of cities to convert their cream into ice-cream and sell this product direct to consumers. This is somewhat surprising, since the largest profits in the cream business have hitherto been made by what may be called the middleman, the city ice-cream manufacturer.

It is a vital matter with all producers to reach consumers direct wherever this is possible. Dairymen, for example, have long recognized the fact that the only way to get fancy prices for butter is to sell it direct to consumers. The same course must be pursued with respect to cream to get fancy prices for this product.

The essential thing in building up a good ice-cream trade is to make the best product possible. The market is glutted with cheap, inferior ice-cream, and the call now is for a high-grade product. Fortunately, the public is beginning to realize that there is positive danger in eating ice-cream made from stale milk or cream, and the public also seems to have begun to understand that the bulk of ice-cream is made with so-called thickeners, like gelatine, corn starch, tapioca, arrow root, and others. Many of the so-called ice-creams contain no cream whatever. The highest quality of ice-cream contains nothing but pure cream, sugar and flavoring.

BULLETIN 203

MAY, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

**COLLEGE OF AGRICULTURE AND
MECHANIC ARTS**

WEST RALEIGH

CORN WEEVILS AND OTHER GRAIN INSECTS.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,

UNDER THE CONTROL OF THE

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

TABLE OF CONTENTS.

	PAGE.
Angoumois grain moth (Fly weevil) (<i>illustrated</i>)	14
Annual loss due to grain insects	5
Bats, feeding on grain moths	22
Birds, feeding on grain insects	22
Black weevil, same as rice weevil (<i>illustrated</i>)	7
Cadelle, the (<i>illustrated</i>)	11
Carbon bisulphide, fumigation with	26
Corn weevils, so called	6
Cost of carbon bisulphide	27
Dark meal worm (<i>illustrated</i>)	10
Destructiveness of grain insects	5
Experiments in fumigation	25
Failure to kill grain insects by fumigation, cause of	27
Fly weevil, same as Angoumois grain moth (<i>illustrated</i>)	14
Fumigation experiments—	
with carbon bisulphide	26
with sulphur	25
Grain attacked in the field	S, 17, 23
Grain beetles, several species	10
Grain moths	13
Granary weevil, similar to rice weevil	9
Importance of grain insects	5
Indian meal moth (<i>illustrated</i>)	17
Life-history knowledge, value of	6
Lime, as a repellent	25
Meal worms, several species	10
Meal snout moth (<i>illustrated</i>)	19
Mediterranean flour moth	18
Mites, feeding on grain insects	22
Methods of control in general	22
Naphthalene flakes, use of	25
Parasites, beneficial	22
Preventive measures, in general	23
Protection of corn by tight husk (<i>illustrated</i>)	24
Remedial measures, in general	22
Rice weevil (Black weevil) (<i>illustrated</i>)	7
Salt, as a repellent	25
Saw-toothed grain beetle (<i>illustrated</i>)	13
Spiders, beneficial	22
Sulphur fumes, for fumigation	25
True grain weevils	6
Work of weevils in old corn (<i>illustrated</i>)	9
Yellow meal worm	11

CORN WEEVILS AND OTHER GRAIN INSECTS.

BY R. I. SMITH, ENTOMOLOGIST.

Like practically all agricultural products, corn and other grains are subject to the attack of numerous destructive insects, some of them commencing their depredations in the ripening grain in the fields, while others abide solely in the barns, storerooms or cribs where the grain is stored. Farmers of North Carolina and, in fact, of all the Southern States, expect a greater or less number of weevils or other insects to be in their granaries each spring, and consider it fortunate when only a few are present. As a general rule, the injury inflicted to the grain is underestimated, and the loss in total weight and feeding value is accepted as an annoying but unavoidable condition.

The actual loss occasioned by insects in whole grain and the various stock foods cannot be accurately estimated; the grain is not only reduced in weight and consequent selling value, but is often rendered wholly unfit for human food and less valuable as food for live stock.

As an example of the extent of the injury caused by grain insects, a consideration of the value of the grain crop will be of interest. The corn crop for North Carolina in 1908 was valued at \$39,631,000 and the wheat crop at \$6,078,000, a combined total of \$45,709,000. Since there are no statistics to show the actual annual injury caused by insects, it may be conservatively estimated at five per cent, which is lower than the actual per cent of damage reported for certain other Southern States in previous years. Five per cent of the total is \$2,285,450, an amount representing the possible annual damage by grain insects to corn and wheat crops alone in North Carolina.

The list of really injurious species of insects attacking stored grain, and the principal feed stuffs manufactured therefrom, number twenty and upwards. There are two true weevils and at least one dozen other forms known as beetles in their adult stage, while we find six common and injurious species whose parents are moths. Ten of the most important and conspicuous of this number are described in the pages following. The principal damage to whole grains is caused by the rice or black weevil and the angoumois grain moth or fly weevil, but the others mentioned are frequently present in destructive numbers. In eastern North Carolina the black weevil probably predominates, but in the western section the fly weevil holds first position. In many localities these two species and others of less importance are found working together, sometimes actually occurring in the same kernels of corn.

For the reader who is not familiar with the grain insects, the illustrations (original photographs by the author) and statements concerning the life-history of each will help to show the importance of this subject. It is not always realized how rapidly these insects—the true weevil, for example—may increase in numbers under favorable conditions, nor is it known by all that grain may become infested in the field before harvest. With species that produce only one generation annually, it is not realized how important is the matter of killing them in the larval and pupal stages, an example being the dark meal worm. These and other points given under the discussion of each species in the following pages are necessary for an intelligent understanding of the grain insect problem.

The presence of insects in grains, meals and food stuffs is not easily prevented, nor is it an easy matter to kill them after once gaining a foothold, but certain preventive and remedial measures may be adopted to avoid a portion, at least, of the annual loss. A portion of this bulletin is devoted to the discussion of the best known and most effective control measures. Attention is called especially to the carbon bisulphide fumigation treatment, as this has for many years been principally recommended for destroying grain insects. The writer's recent experiments show conclusively that fumigation with this substance cannot give satisfactory returns when employed under ordinary farm conditions where grain is stored in cribs or rooms that cannot be made sufficiently tight to hold the poisonous fumes long enough to kill weevils.

The purpose of this Bulletin is partly to give farmers a more accurate knowledge of the various grain pests, and to caution them to use preventive measures wherever possible, and partly to explain the limitations in the use of carbon bisulphide for fumigation of infested grain.

THE GRAIN WEEVILS.

The popular name for all insects working in stored grain is weevil; but restricting ourselves to the correct meaning of the term, there are only two true grain weevils. These are the rice weevil and granary weevil, two closely related species, which in the mature stage are small dark-colored beetles possessing a snout or proboscis about one-third as long as the body, and belong among a group of snout beetles that include such familiar forms as strawberry weevils, corn bill-bugs, plum curculio, acorn weevils, and many others. The grain pest known to farmers as the fly weevil, a species fully as destructive as the true weevils, should be placed in a different class, because of the mature form being a small moth which does no damage other than to lay eggs; and the same may be said of all the grain pests that develop

into moths. The remaining grain insects, which are different forms of beetles in the mature stage, do not belong to the group of snout beetles, and are not properly called weevils.

THE RICE WEEVIL (BLACK WEEVIL) (*Calandra oryzae*, Linn.).

The name corn weevil or black weevil is usually applied to this species, although its original name is rice weevil, so called because of its being first discovered in that grain. The former names are also applied to a near relative, the granary weevil; hence we should preserve the title rice weevil to make this species distinctive. India is thought to be its native home, but the species may now be found in nearly every grain-producing country of the world, and is particularly abundant in the Southern States, but is less numerous farther North.



FIG. 1.—The Rice Weevil or Black Weevil; *a*, full-grown larvæ; *b*, pupa from beneath; *c* and *d*, adults—about five times natural size.

Injury is caused by the adult beetles eating into grain for food and shelter, as well as by the larvæ that feed inside the kernels. Small grains like wheat and rice furnish food for only a single larva in each kernel, but in corn three or four may mature. It has been estimated that one pair will, in the course of a year, produce over 6,000 descendants. The effect on the grain is to reduce the weight materially, and consequently its selling value, and renders the grain unfit for human consumption.

DESCRIPTION AND LIFE-HISTORY.

The mature weevils (Fig. 1, *c* and *d*) average to measure about one-sixth inch, including the snout, which is about one-third the length of the body. The general appearance is dark reddish-brown, but individuals vary from a light brown to nearly black; the thorax presents a network of minute round punctures; the wing covers or first pair of wings bear a more or less distinct red spot near the base and tip of each wing, while the whole surface bears small punctures arranged in longitudinal rows. Underneath these, the second pair of wings are

membraneous and well developed, enabling the beetles to fly to fields remote from the granaries. The snout bears a pair of elbowed antennæ (feelers) and terminates in strong biting jaws.

The larva (Fig. 1, *a*) is white, fleshy and robust, possessing strong, horny, brown jaws. Legs being unnecessary, are not present. When fully grown the larva transforms to a pupa (Fig. 1, *b*) in its burrow, in which stage it shows the general size and outline of the future beetle, but is transparent and white in color.

The eggs are small and white and are laid in minute punctures made in the grain by the jaws of the female weevil. The tiny larva when just hatched commences at once to gnaw toward the center or makes a channel for some distance just under the skin of the grain.

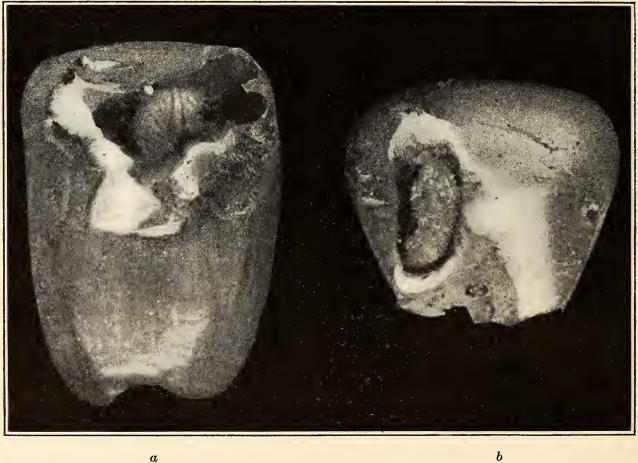


FIG. 2.—The Rice Weevil larva and pupa *in situ* in corn; *a*, larva; *b*, pupa; both enlarged five times.

The channel is always filled with a fine powder, quite different in appearance from the pellet-like excrement left by the larvæ of the angoumois grain moth. When nearly grown the larva provides for the easy escape of the mature weevil by leaving only a thin skin over the burrow, and then quietly transforms to a pupa, which in time changes to the mature weevil.

Four or five generations mature each year. At Raleigh the writer observed adult weevils laying eggs on ripening corn in the field, on September 12, 1908; he also found a few small larvæ. From an ear

of corn collected on this date adult weevils emerged on October 17, showing that in this instance the eggs must have been laid early in September, or possibly in August, because it is known that the period from egg to adult is about six weeks in warm weather. In addition to the weevils that fly to the fields and attack the ripening grain, many continue to breed all summer in the granaries where food is obtainable, and whenever infested grain is kept until the new crop is housed, the weevils are furnished ideal conditions for rapid development. It is impossible to prevent grain from becoming infested in the field, but the farmer can see that no weevils are present in the barns or granaries when the crop is housed. The practice of keeping corn the year round and sometimes putting new corn on top of the remains of the previous year's crop cannot be too strongly condemned.

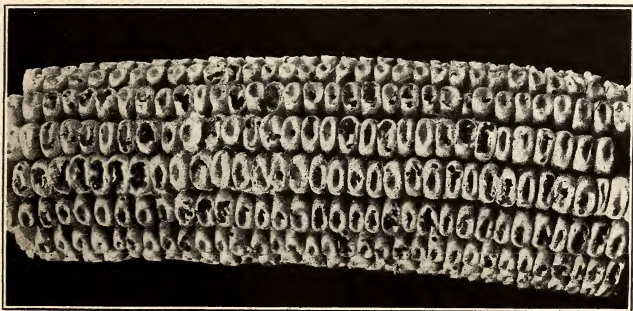


FIG. 3.—Work of Rice Weevils and the Cadelle in two-year-old corn.

Wheat, oats, rice and other grains serve as food for the rice weevil, and may be infested in the field at about the time the kernels are ripening. With corn it has frequently been observed that the ears having a tight husk are seldom attacked by weevils, but we are confronted with the fact that the corn ear-worm (*Alabama argillacea*) frequently makes entrance and exit holes through the husk of the most perfect ears, and by means of these openings the adult weevils enter ears that would otherwise be inaccessible to them.

The general discussion of preventive and remedial measures is given on pages 22 to 27.

THE GRANARY WEEVIL (*Calandra granaria*, Linn.).

In general size, appearance and feeding habits the granary weevil is almost identical with the rice weevil. It may be distinguished, however, by its lack of membraneous wings, consequently being unable

to fly, and by the thorax being sparsely and longitudinally punctured. It is also generally somewhat lighter in color than the preceding species. It requires only passing mention here, for the rice weevil far surpasses it in numbers and destructiveness in the Southern States. Owing to its lack of wings, the granary weevil remains in the barn and corn cribs; hence, where proper precautions are taken to feed or remove all infested corn each fall before the new crop is housed, this species can never become abundant like the preceding one. The granary weevil infests wheat, corn, barley and other grains, but is generally considered as a corn weevil.

GRAIN BEETLES AND MEAL WORMS.

There are nearly a dozen species of beetles that attack grain, meal, bran, middlings, and many food products, and often work side by side with the true weevils. The cadelle, which is described, is nearly always found in the barns and grain rooms of the Southern States, and several smaller species of grain beetles are equally abundant, but do less damage because of their small size. The species that the writer has found most abundant are the following:



FIG. 4.—Dark Meal Worm and parent beetle. Two and one-half times natural size.

THE DARK MEAL WORM (*Tenebrio obscurus*, Linn).

This species, illustrated in Fig. 4, feeds mainly in meal, bran and other stock feeds, but may be found at times in whole grains. They often become abundant in grain bins that are not often entirely

emptied, a good illustration having come under the writer's observation recently, in a barn at West Raleigh where hundreds of the beetles were found during the first and second weeks of May.

There is only one generation each year. The beetles normally appear about the last of April, in this section, and soon deposit small, white, bean-shaped eggs in whatever food is at hand. The eggs hatch in two weeks into small delicate larvæ, which increase rapidly in size, and are said to become fully grown in about three months.

The worms, when grown, are darkish brown in color, with a smooth waxy skin, resembling a wireworm. They attain a length of about an inch and live in this stage without much change during the winter, transforming in spring to whitish pupæ and eventually to mature beetles. These are dull black in color and average a little less than three-quarters of an inch in length. The beetles are nocturnal in habits, scampering rapidly out of sight when suddenly exposed by the opening of a grain box.

The meal worms frequently breed in the bottom of grain bins or in corners where meal, flour or other refuse material has accumulated, but as they develop only one generation a year, thorough cleaning-out of all infested material during July or August, after the eggs are laid, will suffice to control them.

THE YELLOW MEAL WORM (*Tenebrio molitor*, Linn).

Differing from the preceding species in color, but not much in size or habits, the yellow meal worm is frequently found in stock foods, flour mills, bakeries, feed rooms and similar places. The worms are yellow, shading to darker toward each end and near the articulation of each joint, but in other respects do not differ from the dark meal worm. The adult beetles of this species are blackish and shining, instead of dull black, and have certain other points of difference, but their habits are the same as the parents of the dark meal worm.

THE CADELLE (*Tenebriodes mauritanicus*, Linn).

A widely distributed species occurring in all manner of prepared food products, as well as in grain, meal and other stock foods, is illustrated in Fig. 5. The larvæ was given the name "cadelle" in France many years ago, when it was classed as a meal worm, and in recent years some authorities have claimed that this species is predaceous and carnivorous rather than granivorous, but the writer has observed that it possesses both habits. Chittenden states that he has proved it to be both a feeder on grain and other insects. Consequently the cadelle represents an insect that is both beneficial and injurious. In old corn it is particularly destructive, and in my opinion the injury

caused is greater than its beneficial work by destroying other grain insects. It is not uncommon to find cadelle larvæ feeding in grain from which weevils have emerged.

The parent beetle (Fig. 5) is elongate, flattened, and nearly black, measuring about one-third of an inch in length. The larva (Fig. 5) measures nearly three-fourths of an inch when fully grown, its general coloring being whitish, with the head and anal segments dark brown, and the three thoracic segments marked with brown. The body is fleshy and tapers gradually toward the head.

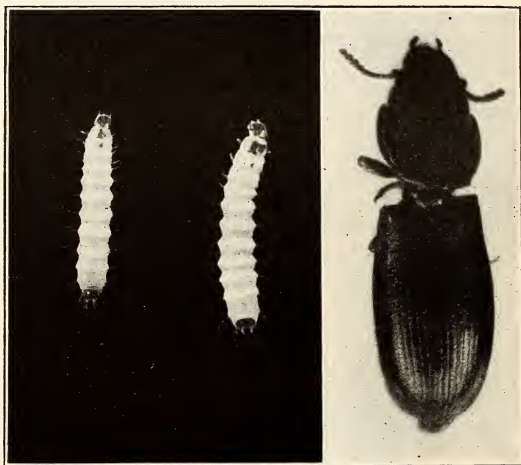


FIG. 5.—The Cadelle; full-grown larvæ twice natural size; parent beetle seven times natural size.

Both the larva and adult feed in the grain, frequently changing their positions, perhaps in search of weevil larvæ, but most assuredly they cause much injury and should be dealt with like any other grain insect.

Only one generation is produced annually, which is very fortunate, as otherwise the species might prove one of our worst grain insects. Recent experiments by the writer have shown that the beetles are more difficult to kill by fumigation with carbon bisulphide than the adult corn weevil, although the larvæ are quite readily destroyed by this treatment.

THE SAW-TOOTH GRAIN BEETLE (*Silvanus surinamensis*, Linn).

This is one of the smallest, but most common, of the insects attacking grain and nearly all food stuffs. Its small size enables it to penetrate the smallest cracks, and its taste for all kinds of food causes it to be found in granaries, storerooms, groceries, pantries and bakeries, even feeding on red pepper. As a grain pest this species does not actually devour enough to render its presence a source of great loss, but it is nevertheless a great nuisance, and infested food stuffs may be rendered unfit for consumption. Both the larvæ and adults have the habit of eating holes in paper bags in search of food.

The mature beetle (Fig. 6, *b*) is only about one-tenth inch in length, much flattened and chocolate-brown in color. The thorax bears six minute points or teeth on each side, which may be seen in the illustration.

The larva (Fig. 6, *a*) is a slender white worm with darker markings, and is very active, moving frequently from one place to another.



FIG. 6.—The Saw-tooth Grain Beetle; *a*, nearly grown larvæ; *b*, parent beetles—both greatly enlarged.

There are said to be six or seven generations annually, the entire life cycle being covered in twenty-four days in midsummer.

The writer's experiments have shown that these beetles are killed by carbon bisulphide fumes a little more easily than are the corn weevils or other grain beetles mentioned above.

GRAIN AND MEAL MOTHS.

We now come to grain insects of which the parents are moths, and among them are found some very destructive species. Only one, the larvæ of the angoumois grain moth, develops entirely in the kernels of grain, either wheat, corn, barley or other cereals, while the remainder have the habit of passing from one grain to another, marking their progress by a silken tube or web, or working their way through meal,

bran or whatever material they occur in, transforming the same into a worthless webby mass. Owing to this habit the meal worms cause damage all out of proportion to the amount of food they actually consume.

In point of importance the angoumois grain moth should stand next to the rice weevil—in some localities, in fact, greatly outstripping it in numbers.

THE ANGOUMOIS GRAIN MOTH (FLY WEEVIL)
(*Sitotroga cerealella*, Ol.).

The Southern farmer generally applies the term "fly weevil" to this species to distinguish it from the rice or black weevil, but the term is hardly appropriate, because the adult flying moth is simply the parent form of the worm that feeds in the grain. This species does not



FIG. 7.—Showing the work of the Angoumois Grain Moth, as often seen in October—slightly enlarged.

attack meal or food products, but lives in the whole grain, a single kernel of corn often furnishing food for two or three larvæ. The characteristic appearance of an infested ear of corn, as sometimes found in the field during October or November, is shown in Fig. 7. Fig. 8 shows an ear from which several generations of moths have emerged, such specimens being frequently found in two-year-old corn.

The moths are seen in Fig. 9, the male always being of smaller size. In color they are light grayish-brown, with lines of black, and

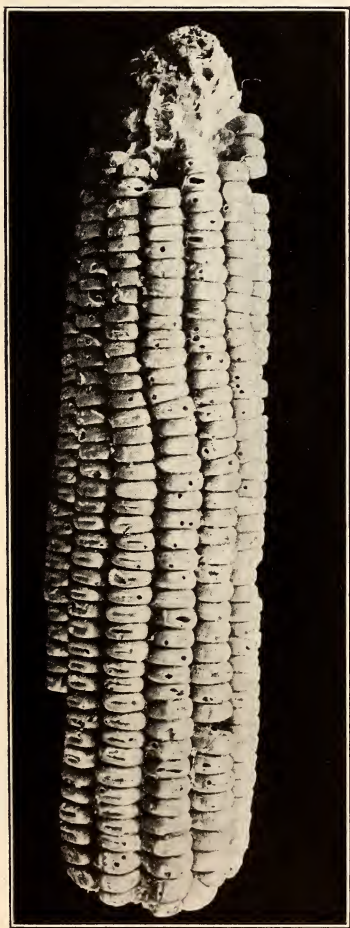


FIG. 8.—Ear of corn from which several generations of the Angoumois Grain Moth have emerged—slightly reduced.

measure across the expanded fore wings a little over one-half inch. The front wings bear a fringe of long hairs on the anal edge, and the hind wings bear a continuous border of the same. The moths are very delicate, easily crushed and readily killed by poisonous fumes.



FIG. 9.—The Angoumois Grain Moth; *a*, female; *b*, male; *c*, male with wings expanded—all two and one-half times natural size.

The larva (Fig. 10, *b*) is white, distinctly segmented and attains a length of about one-quarter of an inch. The jaws are brown and horny. When grown the larva transforms to a light-brown pupa (Fig. 10, *c*) in its feeding place, but provides beforehand for the escape of the adult by leaving over its burrow only a thin skin of the grain, through which the moth easily manages to escape.



FIG. 10.—The Angoumois Grain Moth; *a*, natural appearance of infested kernel; *b*, larvæ in natural position; *c*, pupa, same—all two and one-half times natural size.

The eggs, deposited singly or in clusters, are at first white, but soon turn reddish and hatch in four to ten days, depending on the temperature. Each female lays from sixty to ninety eggs. The larva when hatched is active and soon penetrates the grain, leaving an almost

invisible opening. In about three weeks the larva is fully grown and transforms to the pupa stage. Both larva and pupa are shown *in situ* in Fig. 10 in partially opening kernels of corn.

During the year five or six generations of moths may be produced. Farmers commonly remark that grain becomes infested in spring when large numbers of moths are seen flying in the granaries—thus gaining for them the name “fly weevil”; but in reality the grain is generally first infested in the field. At West Raleigh the writer found, in 1908, that many moths had matured and escaped from ripening corn in the field on September 10. Two days later an ear of corn was taken and placed in a glass jar, and by September 27 thirty-four moths had emerged. From this it is seen that the first brood in the field must mature here as early as the beginning of September, and it may be that the writer missed the first brood. In any event there must be two full broods and probably three during the summer and fall, the winter being passed in the larval stage. In spring the moths commence to emerge in April, and earlier in the warmer sections of the South, and succeeding generations may mature about every six weeks.

Grain in the field is evidently not infested until nearly grown, or in such condition that the first moths mature about when the grain is ripening. It is certainly a bad practice to leave corn cut and stacked in the field during the fall months, for in such condition more ears are exposed to egg deposition than would be if the corn were stored in the grain cribs. The moths will not be present in the granaries during the fall months if proper precautions have been taken to get rid of all infested grain of the previous year's growth.

THE INDIAN MEAL MOTH (*Plodia interpunctella*, Hbn.).

This species is not a serious grain pest, but the writer has reared a considerable number of the moths from corn infested principally with the angoumois grain moth. The usual food of the Indian meal moth larva is said to be dried fruit, seeds, nuts, roots and condiments as well as meal and grain products.

The parent moth is shown in Fig. 11. The fore wings expand a little over one-half inch, and may be described as having the inner third dirty whitish-gray, and the outer two-thirds reddish-brown. The hind wings are of a uniform light-gray color bordered with a fringe of hairs. When seen in houses they are frequently mistaken for clothes moths.

The larva or caterpillar reaches a size of about three-eighths of an inch, and unlike the species just mentioned, does not live in a single kernel of grain. On the other hand, they pass from one place to another, spinning large quantities of silk and fastening the particles of food together. It is claimed that they have a special fondness for the

embryo of wheat, one caterpillar often ruining dozens of kernels for seed or food purposes. The entire life cycle may be passed, from egg to adult, in five weeks in warm weather; hence several generations a year may be expected.



FIG. 11.—The Indian Meal Moth, enlarged two and one-half times.

The parent moths are easily killed by poisonous fumes and the larvæ are more easily killed than those of the angoumois grain moth or corn weevil, which live entirely within the grain.

THE MEDITERRANEAN FLOUR MOTH (*Ephestia kuehniella*, Zell).

As a pest in stored grain this species is of slight importance, but it has no equal in destructiveness in flour mills, and in the absence of its favorite food, such as flour or meal, it will attack grain and flourishes on bran and cereal foods. The writer has bred this species from cotton-seed meal. The history of this insect commenced in 1877, when it was discovered in a flour mill in Germany and later invaded Belgium and Holland. In 1892 it was reported as occurring in mills in Canada and during 1895 in New York and Pennsylvania.

The moth is described as having a wing expanse of a little less than an inch, the fore wings being blackish-gray with transverse black markings, the hind wings being dirty whitish color.

The larval stage is really a caterpillar that reaches a length of one-half inch and is pink in color. Its full growth is attained in about forty days, after which it changes to a reddish-brown pupa in a silken cocoon.

The caterpillars have the habit of spinning silken tubes wherever they travel, feeding from the mouth of the tube, and it is this habit that renders them so injurious. Infested flour or meal becomes matted together and lumpy, clogging the machinery in mills and rendering the material in which they feed unfit for human consumption. When such infested material is discovered it should be destroyed immediately, and wherever mills are found infested, prompt measures

should be taken to exclude the pest by destruction of the insects in infested material, by thorough cleaning and by fumigation. Afterward, a strict inspection and quarantine should be established to prevent the entrance of infested material. Farmers need not fear this pest, but millers should be on the lookout for its appearance.

THE MEAL SNOOT MOTH (*Pyralis farinalis*, Linn).

This is a larger and in many respects more conspicuous species than the ones already described. The writer's attention was attracted to this insect in March, 1909, by finding hundreds of the worms and pupæ in grain bins in one of the Experiment Station buildings. These bins had been in use for a number of years, and it seems that they have not often been entirely emptied, and it is just that condition,



FIG. 12.—The Meal Snout Moth, enlarged two and one-fourth times.

where the bottom of grain bins are never reached, that induces the rapid increase of all kinds of meal worms. The infestation thus found furnished good material for a fumigation experiment, which will be mentioned, and for securing specimens in all stages.

The parent moths are illustrated in Fig. 12 nearly two and one-half times natural size. They measured across the expanded wings from seven-eighths to one and one-eighth inches, and are considerably larger than described by most writers. The females are always larger than the males. The coloring is light or dark brown with reddish reflections, and the wings are crossed by wavy white lines. The moths are nocturnal in their habits and fly quickly when disturbed.

The caterpillars are rather slender and average to measure one inch in length; the head is shiny brown; the first thoracic segment and the anal segments are distinctly orange-yellow in color. In Fig. 13, *a*, is shown its general appearance. Its feeding habits are somewhat like

the preceding species, a delicate silken tube being spun as it feeds. The feeding tube (Fig. 14) taken from a bin of bran, and showing the

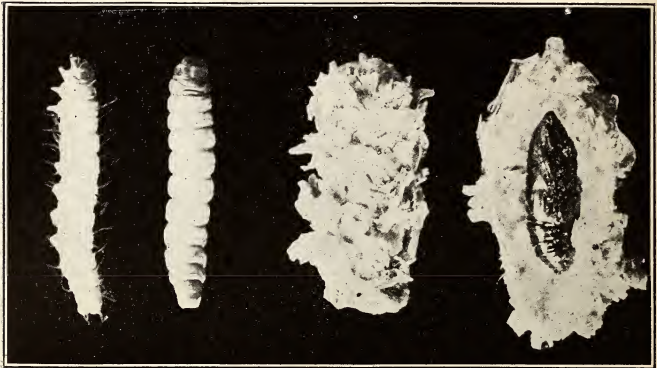


FIG. 13.—The Meal Snout Moth; *a*, larvæ; *b*, cocoon; *c*, pupa in an opened cocoon—
all two and one-fourth times natural size.

adhering particles, is constructed out of sticky, silken threads which are always covered with whatever food the worms are working in, whether it be meal, bran, whole wheat or other grain.



FIG. 14.—Feeding Tube made in bran by the larva of the Meal Snout Moth—slightly reduced.

The pupa stage is assumed in a tough silken cocoon covered with particles of food, as illustrated at Fig. 13, *b*, an open cocoon being

shown at *c*. The pupa is light reddish-brown and of the form illustrated. Fig. 15 shows a small section of a bran bin covered with meal-worm cocoons, which were equally numerous on all sides.

Concerning the life-history, this species passes the cold months in the larval stage, and at West Raleigh the first moths emerged this year on April 20. Three or four generations annually are credited to this insect.

As a grain pest the meal snout moth is not of great importance. Among its various foods may be mentioned hay, straw, seeds, dried plants, all grains and the products made therefrom, and masses of



FIG. 15.—Showing cocoons of the Meal Snout Moth on the side of a grain bin in which bran was kept.

refuse vegetable matter, such as potatoes. Evidently this insect flourishes best in moist surroundings and is not liable to thrive in material stored in a dry, clean place.

As remedial measures the destruction of infested material and cleaning-out of places where the worms are discovered are by far the best. Fumigation with carbon bisulphide might be effective against the caterpillars in a perfectly tight box or bin, but it is doubtful if the pupa in their cocoons can be killed by any ordinary strength. In the bran bin in which the worms were discovered (see Fig. 15), as already mentioned, carbon bisulphide was used this year at the rate

of five, ten, fifteen and twenty pounds, respectively, per thousand cubic feet, on April 7, 10, 14, and 15, and after the fourth treatment some of the pupæ were alive and have since transformed to moths. This bin was apparently air-tight except for a crack on the hinged edge of the cover. The details of the experiment need not be discussed here, except to explain that the first and second treatments killed only a small per cent of worms, the third killed nearly all, and the fourth would have been considered a perfect treatment had not a few moths issued later.

PARASITES AND PREDACEOUS ENEMIES.

Nature provides in the form of parasites a means for preventing the unlimited increase of nearly all injurious insects. Even the larval stages of insects in grain are killed frequently by these beneficial parasites, which are small black flies in the adult stage. Two or three species of chalcis flies have been bred from the larvæ of corn weevils and the angoumois grain moth. The other grain moths and meal worms are known to have parasitic enemies whose work in the aggregate is a considerable help toward controlling grain insects. It is not uncommon to find larvæ and pupæ of the angoumois grain moth that have been killed by parasites. Farmers can easily verify these statements by enclosing some weevil-infested grain in a glass jar and observe the minute black flies that emerge.

Among the predaceous enemies may be mentioned mites, spiders, insects of nocturnal habits, birds and bats.

The mites are diminutive, white, spider-like animals, that prey on many species of grain insects. Spiders occurring in the granaries and mills spin webs that entrap many of the grain moths, while bats hover around the grain bins and barns for the purpose of feeding on the moths. The cadelle, already mentioned, feeds on other grain insects, and probably does considerable good in this respect, but its presence is not desirable, as it also does much injury.

GENERAL CONTROL MEASURES.

These may be either preventive or remedial, or a combination of both, as it might properly be termed, when such measures are taken as tend to kill the adult parent forms, which, in many cases, do no damage aside from laying eggs for another generation. Under the head of preventive measures, several things may be mentioned, but no one alone will solve the problem, and the following discussion is given mainly as a suggestion based on the known habits of these insects. Fumigation with carbon bisulphide has in the past been the chief remedy, and is yet to a certain extent, but the reader is requested to note the results of recent experiments that show how difficult it is to confine the poisonous fumes in ordinary granaries long enough to kill

the various insects that may be present. The old adage "an ounce of prevention is worth a pound of cure" is just as applicable in this connection as it is in troubles of other nature.

PREVENTIVE MEASURES.

Grain first becomes infested through one of two sources: (1) the insects may attack the ripening grain in the field, and (2) the insect may live continuously in barns and granaries ready to commence work in the newly harvested crop. The second source of infestation is more easily prevented than the first.

Field Infestation.—Some species like the rice weevil, angoumois grain moth, saw-tooth grain beetle and a few other small grain beetles are usually found in ripening grain, particularly corn. As a general rule, grain is partially matured, or at least nearly grown, before it is attacked by insects, which of course come from the places in which the grain is stored during the winter. As it cannot be hoped to kill all the insects in stored grains and thus prevent their going to the fields, an effort must be made to prevent them from getting back again in the new grain. Small cereals like wheat and rye should be threshed as soon as dry enough, as that process will kill many of the adult insects and dislodge the eggs. The adult angoumois grain moth is easily crushed and the threshing and handling of the grain destroys many of them. After it is threshed the grain should be stored in tight bins or in sacks, the latter being preferable, because the moths that mature will die without escaping. Whenever the grain, if infested, can be fumigated in practically air-tight boxes or receptacles, carbon bisulphide should be used when the grain is first housed. The practice of storing grain in large bulk is to be commended, as a protection from weevils or grain moths, for then only the surface layers are exposed. This is in direct accord with the recommendation that grain should not be cut and stacked in the field for several months. Such practice tends to allow the insects to infest all the grain more readily than if the same were stored in a large bulk.

Concerning corn particularly, the tight husk offers much protection, and in the field the angoumois grain moth or rice weevil would be excluded almost completely from ears with a husk fitting tightly over the end, were it not for the corn ear-worm, which frequently makes entrance and exit holes, that furnish easy entrance for the grain moths or beetles. However, the presence of the ear-worm is an argument in favor of housing the grain as early as practicable. The longer it is left in the field the greater will be the number of ears infested. Of course, if the farmer does not see that the barns and granaries are free from insects when the grain is stored, the extent of the field infestation is of less importance.

Cleanliness.—The ideal place to store grain is in a special building separated from the barns, but when grain must be stored in the latter place all old infested grain should be used before the new crop is housed, and precautions should be taken to guard against leaving heaps of waste corn, or other material in which the grain insects may be feeding. The writer has known many farmers to place new corn on top of a few bushels of old corn literally being devoured by the weevils and other insects. Farmers will also often boast that their bins or cribs are never emptied. This practice cannot be too strongly condemned.

Storing Corn in the Husk.—It has often been observed that unhusked corn is less liable to weevil injury, and this is true with varie-



FIG. 16.—Two-year-old Corn showing protection from weevils afforded by a tight-fitting husk—about one-half natural size.

ties that have a tight-fitting husk, when not too badly injured by the ear-worm. In Fig. 16 is shown an ear of corn two years old which was taken from the same lot as the one shown in Fig. 3. It is seen from this cut how the tightly fitting husk acted as a protection. In the same lot, however, the ears on which the husk was loose were all badly injured. When it is considered that corn is nearly always first infested in the field, the value of storing unhusked corn seems somewhat doubtful.

Moth Traps.—All the grain moths are nocturnal in habits and may be attracted to lights. By placing in the corn cribs wide shallow pans containing a little kerosene, with a lantern suspended just above or set in the middle, hundreds of moths may be trapped. They will fly to the light and fall into the pan, and even if they escape again the

kerosene will kill them. These traps may be used in the spring when the angoumois grain moth commences to emerge, or at any other time when they are abundant.

Repellents.—Various substances have been tried for sprinkling over grain in storage to repel the parent insects, but few are of practical value. Salt, air-slaked lime or powdered sulphur are said to be employed with some success. Naphthalene flakes act as a powerful repellent, but its use is objectionable, and the same is more or less true of the other substances named.

FUMIGATION TREATMENT.

The destruction of insects in stored grains or cereal products, by poisonous fumes, has been recommended by so many writers that many people have come to the conclusion that the treatment must be perfectly reliable; but experience would teach otherwise. Carbon bisulphide is the chief dependence, but other substances, such as benzine, naphtha, carbon tetrachloride, burning sulphur fumes and hydrocyanic acid gas, have been suggested. The last named is a deadly poison, and if used for fumigating in a perfectly air-tight space would be certain death to all grain insects. It is too dangerous, however, to be recommended for general use.

Sulphur Fumes.—The fumes of burning sulphur, chemically known as sulphur dioxide, have long been known as a powerful fumigant and disinfectant, and have been used successfully for destroying rats and other animals. For several years it has been recognized that sulphur fumes would kill insects. During the past fifteen months the writer has made many experiments to see if this knowledge could not be made use of in killing grain pests. The results proved conclusively that sulphur fumes will kill grain insects, not only the adult forms, but the larvæ and pupæ of the rice weevil and angoumois grain moth as well; but the germinating power of the grain so treated is destroyed or much weakened. It was found that the fumes produced by burning two and one-half pounds of sulphur either in a moist or dry atmosphere of one thousand cubic feet space, for twenty hours, would kill all exposed adult insects and practically all the young stages in the grain, but that this also destroyed its germinating power. In making these experiments the sulphur was placed in a metal dish, one side of the pile wet with alcohol, which was sufficient to start the sulphur burning by simply applying a match.

While this treatment cannot be recommended for general fumigation, there is no doubt of its being the easiest and cheapest method of fumigating corn cribs, granaries and similar places whenever they are being cleaned out and freed of insects in preparation for the reception of more grain. The amount stated above will kill all insects

if the space is made practically air-tight, but if the fumes escape through cracks the amount necessary for successful fumigation cannot be estimated, and the same statement would be true of any poisonous gas.

Carbon Bisulphide Treatment.—Carbon bisulphide is a heavy, clear, foul-smelling liquid, which evaporates rapidly when exposed in shallow dishes. The vapor is a deadly poison when confined in sufficient quantity, and has been extensively used for killing all kinds of insects in stored grain, cereal products, or other material. The amount required is claimed by excellent authorities to be only one pound in 1,000 cubic feet of space, provided there is no escape of the poisonous vapor for about twenty-four hours. This means ideal fumigating conditions, which cannot be secured under ordinary circumstances. The question therefore becomes, what amount of carbon bisulphide must be used to overcome the loss due to leakage? The writer has recently conducted numerous experiments, all of them showing that the diffusibility of carbon bisulphide fumes is greater than generally supposed, and that fumigation of corn, for instance, in a well made, apparently tight grain bin, may not result in killing weevils unless twenty or more times the usually recommended amount be used.

The vapor of carbon bisulphide is 2.64 times heavier than air, so that it settles rapidly if exposed on the top of grain or whatever is being fumigated. This fact has led many people to suppose that it can be used successfully in any space with air-tight sides and bottom, provided the top is covered to exclude currents of air, and that under these conditions the heavy vapor would not escape. It does, however, diffuse in the same manner as other gases, although not as rapidly as those of less specific gravity, and recent experiments have shown that if there is any chance of leakage from the top, the expected results will not be obtained. Where will we find a farmer's grain box, corn crib, or storeroom that can be made air-tight without prohibitive trouble and expense? Not in North Carolina or any other farming district!

One writer has made the statement that, "one pound of carbon bisulphide poured over one hundred bushels of corn will kill all the insects even in open cribs," and farmers are constantly being advised to fumigate with two or three pounds to one thousand cubic feet of space, in fairly tight rooms.

RESULTS OF EXPERIMENTS.

The adult grain moths are killed by the vapor from a small quantity of carbon bisulphide, but the grain beetles require a much greater strength, and it is even more difficult to kill the young stages, larva and pupa, of the rice weevil and angoumois grain moth, in their bur-

rows. The writer has made numerous experiments with grain insects in all stages, using a practically air-tight fumigating room, one having a padded refrigerator style door and the inside walls covered with asbestos. In this it was found that three pounds of carbon bisulphide to one thousand cubic feet, fumigating for twenty-one hours, killed practically all adult insects, but not over seventy per cent of the larvæ and pupæ of the angoumois grain moth or rice weevil.

For an experiment corresponding to farm conditions a grain box of about forty cubic feet capacity was used; the sides were made of matched boards and the floor of concrete; the top edges were covered with sacks and the hinged cover nailed down on three sides when fumigation commenced. The bin was about one-third full of bran. Carbon bisulphide was used by exposing it in shallow dishes near the cover, tests being made with ten, fifteen and twenty pounds, respectively, to one thousand cubic feet space, for twenty-four to twenty-six hours. Larvæ, pupæ and adults of both rice weevil and angoumois grain moth and adult cadelle beetles were used in each test. It was found that the greatest strength used did not kill all the insects twelve inches below the cover, and the average result was not equal to that obtained by using three pounds for twenty-one hours in the tight fumigating room, already described. In view of these results, the writer is forced to conclude that carbon bisulphide, at any reasonable strength, cannot be successfully used for fumigating grain in ordinary corn cribs, grain boxes or storerooms.

Small quantities of infested grain can be fumigated in absolutely tight boxes or barrels by using about one ounce to three bushels. The top must be rendered air-tight, not simply covered with blankets or canvas. Fumigation should continue for about twenty-four hours.

Caution.—The vapor of carbon bisulphide is inflammable and explosive, hence those who use it must be certain that no lighted lanterns or fire of any kind be brought around where fumigation is being made. Any supply on hand should be kept securely sealed and placed in a ventilated room. As a further precaution it may be marked "Inflammable."

The purchase price is about thirty to thirty-five cents a pound from retail druggists, but as low as eight or ten cents per pound when ordered from the manufacturers, who make a commercial grade especially for fumigating purposes.

BULLETIN 204

JUNE, 1909

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

**COLLEGE OF AGRICULTURE AND
MECHANIC ARTS**

WEST RALEIGH

**SOME FACTORS INVOLVED IN SUCCESSFUL
CORN GROWING.**

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

**THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION,**

**UNDER THE CONTROL OF THE
TRUSTEES OF THE A. AND M. COLLEGE.**

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Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

**N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.**

TABLE OF CONTENTS.

	PAGE.
Introduction	5
Starting Work	5
Testing Varieties.....	6
What is a Variety?.....	7
Early Maturing Varieties.....	8
Medium Maturing Varieties.....	9
Late Maturing Varieties.....	9
Varieties Adapted to Eastern or Coastal Section.....	10
Varieties Adapted to Piedmont Section.....	10
Varieties Adapted to Mountain Section.....	11
Northern Versus Southern Varieties.....	12
Factors Affecting Period of Maturity.....	14
Effect of Variety.....	14
Effect of Soil.....	16
Effect of Season.....	18
Effect of Elevation.....	18
Effect of Latitude.....	18
Effect of Fertilization.....	20
Effect of Date of Planting.....	21
Some Largely Controllable Factors Affecting Yield.....	22
Earliness in Maturity.....	22
Seed Selection	22
Methods of Improvement.....	23
Importation of Seed.....	23
Buying Seed	25
Acclimatization of Corn.....	26
Field Selection of Seed.....	28
Uniformity in Height of Ears.....	28
Barn Selection	29
Result of Proper Seed Selection.....	30
Field Selection and Growth of Seed in an Isolated Field.....	30
Characteristics to Consider in Seed Selection.....	32
Percentage of Grain.....	32
Height of Ears and Stalks.....	32
Number of Ears per Stalk.....	32
Which of Two Ears to Select.....	34
Large Versus Small Ears.....	34
Stalks	36
Ears	36
Position on Stalk.....	36
Shank	38
Shape	38
Color	38
Size of Cob.....	38

	PAGE.
Characteristics to Consider in Seed Selection—	
Ears, Length and Circumference.....	38
Filling of Butts and Tips.....	38
Number of and Distance Between Rows of Kernels.....	38
Kernels	38
Vitality of Seed.....	40
Nubbing Ears	40
White Versus Yellow-Eared Varieties.....	40
Relation of Characters.....	41
Antagonistic Characters	41
Associated Characters	42

SOME FACTORS INVOLVED IN SUCCESSFUL CORN GROWING.

By C. B. WILLIAMS, DIRECTOR.

Information concerning proper methods of selecting seed of different farm crops is of vital importance to farmers, for the same thought and effort put into few other operations of the farm bring such good financial returns. A few hours spent in intelligent field selection of seed of corn each year may be expected to lead to an annual increase of two to five bushels more per acre from these seed than from those selected by the ordinary methods.

In consideration of the promise in this neglected field of work in North Carolina, and that over forty-seven per cent of all land cultivated in the State is devoted to corn, with the use of something like 450,000 bushels of seed corn and a small average annual yield of 13.4 bushels of shelled corn per acre, the Experiment Station six years ago began experiments to determine the relative value of different varieties of corn as producers of shelled corn per acre. During the time covered by these trials many cases in which one or more varieties have produced from five to ten bushels more per acre than other varieties have been observed. Conjointly with these experiments, seed selection work has been carried on with the hope of ascertaining much practical information, the application of which by farmers would lead to materially increased yields of this cereal.

It should be borne in mind, in the beginning, that the underlying principles of plant and animal improvement are almost identical, and that similar methods to those which have been adopted in the improvement of the various breeds of live stock must be followed by those who wish to grow plants of increasing productiveness. It must also be remembered that as intelligent feeding and good care stand to animal breeding, so do proper fertilization and thorough cultivation of the soil stand to plant breeding or improvement; for if proper food and care are not furnished both plants and animals, improved breeding will not only be impossible, but retrogression inevitable. With the same thought and care, results are secured much quicker with plants than with animals, as a completed growth is obtained in one year with most plants, while with animals it requires several years to secure complete knowledge of what one has obtained by a certain cross.

STARTING WORK.

The method that is being followed by the Station is to conduct comparative tests of all the known varieties of promise grown and offered for sale in this and nearby States through a sufficient number of years to secure average weather conditions.

With the variety or varieties demonstrated by these tests to be the most prolific of shelled corn per acre, field seed selection for further improvement was begun and systematically continued; having uppermost in mind, in selecting seed, total yield per acre. By this means it has been observed that the yielding power of a variety may be greatly increased within a few years.

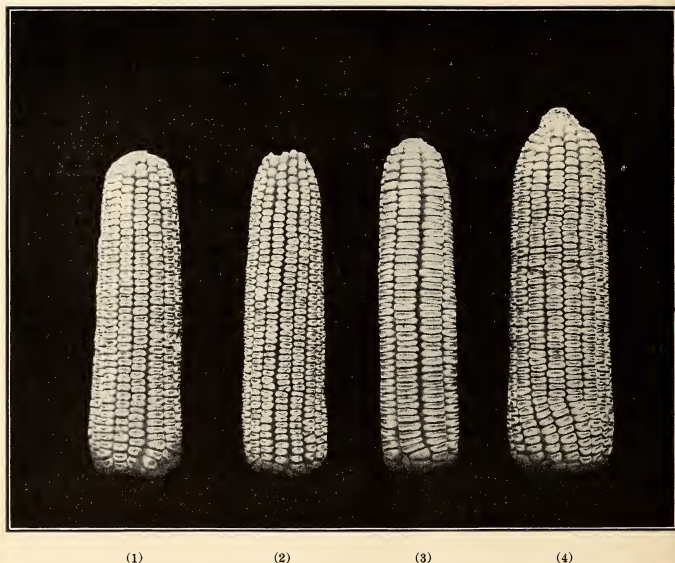


FIG. 1.—Type Ears of Varieties: (1) Sharber's; (2) Jackson's Whitecap Prolific; (3) Hickory King (Virginia); and (4) McAuley's White Dent.

TESTING VARIETIES.

The testing of varieties of all agricultural crops is of the most fundamental importance, as is evidenced by the differences in yield of different varieties grown side by side in the same field, on the same type of soil, with identical cultivation and fertilization; these differences being due largely to the inherent qualities of the seed of the individual varieties which have been transmitted from parent to progeny.

During the past six years on the Station farm something over seventy-five varieties of corn have been studied in comparative field tests. The number of varieties in the different tests have ranged all the way from nineteen in 1903 to sixty-eight in 1908. The different tests of varieties were conducted as nearly under the same conditions of soil, fertilization

and cultivation as it was possible to provide. To eliminate inequalities in the character of the land, if any, the varieties were planted each in separate rows, arranged consecutively, and this plan was repeated from three to five times, varying with the length of the rows, in order to give the desired acreage to each variety. By taking these precautions the results obtained should be reliable and highly valuable.

WHAT IS A VARIETY?

A variety is supposed to represent a class of plants with one or more distinguishing characteristics, but with a cereal like corn, which mixes



FIG. 2.—Type Ears of Varieties: (5) Cocke's Prolific; (6) Weekley's Improved; (7) Shellem's Prolific; and (8) Wilson's Success.

so freely that variety does not mean much unless proper precautions have been exercised in its growth.

Take some variety of corn—say Cocke's Prolific—that has been bred carefully and intelligently for about an hundred years for high yield of shelled corn per stalk, and grow it continuously in or adjacent to a field of inferior corn, and in a very short time, especially if proper seed selection is not practiced, it will give much smaller yields when grown under the same conditions than the original pure-bred corn; this being

due to the fact that you no longer have pure Cocke's Prolific, but a mixture of scrub and Cocke's Prolific corn. This fact emphasizes the importance of securing seed from reliable parties.

EARLY MATURING VARIETIES.

Leaming Yellow, Iowa Silvermine, Riley's Favorite, Reid's Yellow Dent, Boone County White, Boone County Special and Pool's are seven of the earliest varieties in maturing that have thus far been studied at the Station farm. These, with the exception of Pool's, which is from the upper Piedmont section of this State, were all originated and brought



FIG. 3.—Type Ears of Varieties: (9) Dodson's Prolific Shoepeg; (10) Culpepper's Extra Prolific; (11) Biggs' Seven-ear; and (12) Brake's.

for the tests from the Western Central States, where they have been accustomed to a comparatively short growing season, which accounts largely for their inherent tendency to early maturity when grown under North Carolina conditions. Earliness, however, is not considered an important requisite with corn for this climate, except, possibly, where it is grown in the mountainous section of the State, or where corn, of necessity, has to be planted late, after the maturity of some truck crop, like Irish potatoes. Under these circumstances it may be well to use one of the varieties mentioned above, especially if experience has taught

the farmer that local varieties do not thoroughly mature before frost. Under North Carolina conditions of climate and soil these varieties will usually mature from planting in one hundred to one hundred and ten days.

MEDIUM MATURING VARIETIES.

Hickory King, Biggs' Seven-ear, Cocke's Prolific, Wyatt's Improved Yellow, MacMackin's Gourdseed, Peele's Prolific and Farmers' Favorite mature at a medium date in the fall, and some of these are the best yielders grown in the State. All these will usually mature on the different types of soil of North Carolina east of the mountains in one hundred and ten to one hundred and twenty days.



FIG. 4.—Type Ears of Varieties: (13) Williams'; (14) Krimminger's Improved; (15) Osborne; and (16) Farmers' Favorite.

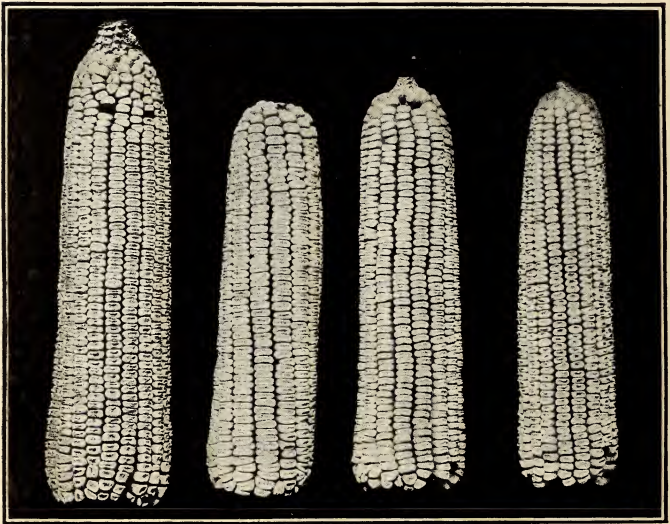
LATE MATURING VARIETIES.

It has been found that Gourdseed, Hastings' Prolific, Mosby's Prolific, Brake's, Harris' Improved, Williams', Osborne, Horsetooth, Holt's Strawberry, Sanders' Improved, Fredonia's Pride, Latham's Improved, Weekley's Improved, Marlboro Prolific, Henry Grady, Bagley's Improved, Cleckler's Improved, Cooper's Improved, Jarvis' Improved, Fry's Improved and Sharber's, in about the order named, are some of the latest maturing varieties tested during the past four or five years. These

varieties are vigorous growers and generally produce large, tall stalks, and many of them have evidently been bred to produce one large ear per stalk. In this climate they will mature usually in one hundred and twenty to one hundred and thirty-five days.

VARIETIES ADAPTED TO EASTERN OR COASTAL SECTION.

For the sandy and fine sandy loam soils of the eastern and southeastern portions of the State, Cocke's Prolific, Biggs' Seven-ear, Weekley's Improved, Sanders' Improved, Hickory King, Holt's Strawberry,



(17) (18) (19) (20)
FIG. 5.—Type Ears of Varieties: (17) Harris' Improved; (18) Whelchel's Dent; (19) Cooper's Improved; and (20) Peele's Prolific.

American Queen, Bagley's Improved, Brake's, Cooper's Improved, Jarvis' Improved and Latham's Improved are recommended as good varieties for planting, if pure seed are secured. Of these varieties Biggs' Seven-ear, Weekley's Improved, Cocke's Prolific and Sanders' Improved, in the order named, are the most prolific. Bagley's Improved, Jarvis' Improved and Brake's possess the largest ears.

VARIETIES ADAPTED TO PIEDMONT SECTION.

It has been found from a testing of a large number of varieties during the past six years that Biggs' Seven-ear, Sanders' Improved, Weekley's

Improved, Cocke's Prolific, Marlboro Prolific, American Queen, Brake's, Holt's Strawberry, Southern Beauty, Bagley's Improved, Farmers' Favorite, Boone County White, Hickory King and Horsetooth are the largest yielders of shelled corn per acre of all the varieties thus far tested for elevations below about 2,500 feet. These are all white-eared varieties, with the exception of Holt's Strawberry, and are medium to medium late in maturity. It will be observed that many of these are the leading varieties recommended for the eastern portion of the State, but the order as yielders of the varieties is somewhat changed.

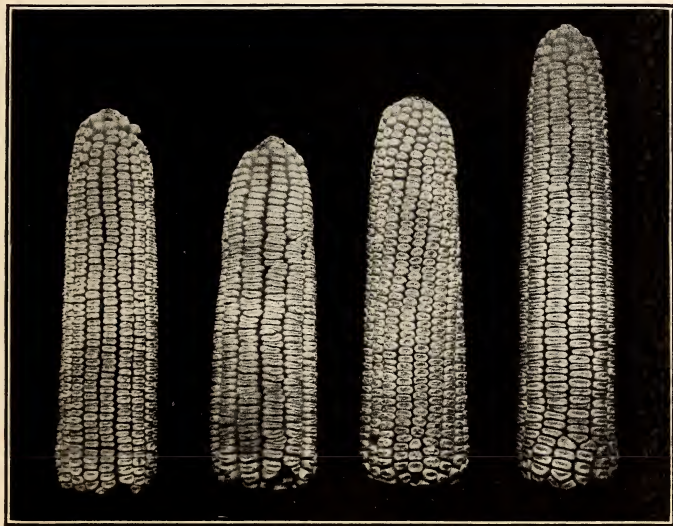


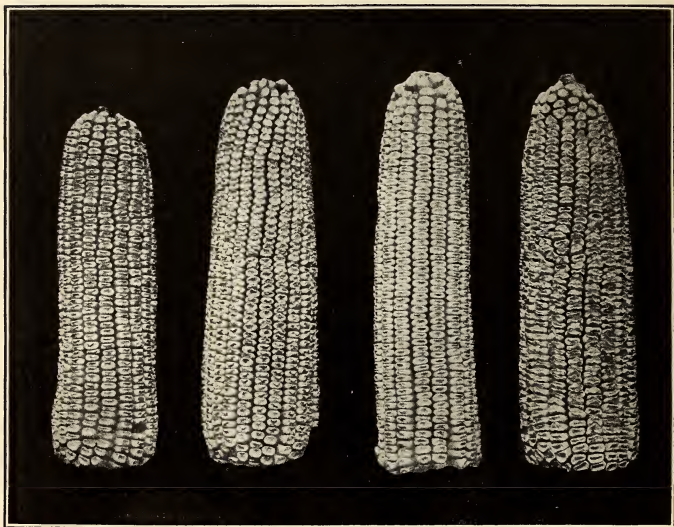
FIG. 6.—Type Ears of Varieties: (21) Goodman's Prolific; (22) Columbian Beauty; (23) Jones' White; and (24) Wright's Improved.

VARIETIES ADAPTED TO MOUNTAIN SECTION.

For those portions of the transmontane region elevated more than 2,500 feet above sea level, and which are devoted to the growth of corn, Boone County White, Leaming Yellow, MacMackin's Gourdseed, Riley's Favorite, Iowa Silvermine and Reid's Yellow Dent are suggested as varieties of dent corn which may be grown to good advantage. For those mountain plateaus elevated about 2,800 to 3,000 feet and which have quite cool nights it will be found that the flint types of corn will do well.

NORTHERN VERSUS SOUTHERN VARIETIES.

As pointed out elsewhere in this Bulletin, the best of the northern-grown varieties of corn have not proven to be the heaviest yielders for the cismontane portions of North Carolina. Neither have varieties coming from the far South yielded as well as the best of those seed which have come from nearer home. In the Station tests, Biggs' Seven-ear, a North Carolina originated variety, has as an average of three years' results, produced 2.4 bushels more of shelled corn per acre than has Reid's Yellow Dent, originated in Illinois, and 4.2 bushels more than



(25) (26) (27) (28)
FIG. 7.—Type Ears of Varieties: (25) Cleveland's Pure White; (26) Fredonia's Pride; (27) Thomas' Improved; and (28) Horsetooth.

Mosby's Prolific, bred in southern Mississippi. Southern corn generally produces a larger and taller stalk, and bears the ears at a greater height, than do those varieties brought from higher elevations and latitudes. The northern varieties, on the other hand, produce a larger ear in proportion to the size of the stalk than do Southern varieties, as is shown by the results contained in Table I. It will also be noted from these data that the percentage the ear is of total plant of both Southern and Northern varieties increases, with only four exceptions, as the yields are made better. The average percentage of ear of total dry plant, as an average of four years' tests, is, for the five Southern varieties, 40.9 per

TABLE I.—SHOWING FIVE YEARS' YIELD OF GRAIN AND EAR PERCENTAGE OF TOTAL PLANT OF SOUTHERN AND NORTHWESTERN VARIETIES OF CORN WHEN ALL WERE GROWN UNDER THE SAME CONDITIONS.

VARIETIES.		SOURCE OF SEED.															
		1903.			1904.			1905.			1906.			1907.			Average of Four Years.
		Yield of Grain per Acre— Bushels.	Plants— Total— Per Cent.	Yield of Grain per Acre— Bushels.	Plants— Total— Per Cent.	Yield of Grain per Acre— Bushels.	Plants— Total— Per Acre.	Yield of Grain per Acre— Bushels.	Plants— Total— Per Acre— Bushels.	Yield of Grain per Acre— Bushels.	Plants— Total— Per Cent.	Yield of Grain per Acre— Bushels.	Plants— Total— Per Cent.	Yield of Grain per Acre— Bushels.	Plants— Total— Per Cent.	Yield of Grain per Acre— Bushels.	Plants— Total— Per Cent.
<i>Southern Varieties.</i>																	
Cocke's Prolific	North Carolina	20.2	41.1	24.8	42.9	31.9	56.4	24.4	---	15.9	30.0	23.2	42.6	---	---	---	---
Weekley's Improved	North Carolina	19.8	44.0	22.1	40.8	28.1	48.4	20.8	---	23.7	36.6	23.4	42.5	---	---	---	---
Sanders' Improved	Georgia	23.2	42.2	25.1	43.2	31.7	49.0	21.2	---	20.2	33.8	25.1	42.1	---	---	---	---
Cocke's Prolific	Tennessee	20.1	39.4	20.6	43.4	25.9	43.3	22.3	---	18.4	31.7	21.3	39.5	---	---	---	---
Mosby's Prolific	Mississippi	19.5	38.1	21.5	39.8	24.7	42.8	20.5	---	14.6	31.3	20.1	38.0	---	---	---	---
Averages	---	20.6	41.0	22.8	42.0	28.5	48.0	21.8	---	18.6	32.7	22.6	40.9	---	---	---	---
<i>Northwestern Varieties.</i>																	
Iowa Silvermine	Illinois	15.7	36.9	20.7	48.6	26.9	58.3	21.4	---	17.6	45.3	20.2	47.3	---	---	---	---
Leaming Yellow	Ohio	19.4	46.6	23.7	55.0	29.6	63.6	20.5	---	19.4	48.9	23.0	53.5	---	---	---	---
Reid's Yellow Dent	Illinois	18.2	45.4	25.1	51.9	28.3	57.1	21.6	---	20.3	42.5	23.0	49.2	---	---	---	---
Riley's Favorite	Indiana	15.1	44.0	23.7	50.7	27.3	57.9	20.2	---	20.1	44.1	21.6	49.2	---	---	---	---
Boone County White	Indiana	14.4	37.9	21.8	47.4	29.2	54.4	22.7	---	21.0	44.8	21.6	46.1	---	---	---	---
Averages	---	16.6	42.2	23.0	50.7	28.3	58.3	21.3	---	19.7	45.1	21.9	49.1	---	---	---	---

The data in this column do not embrace the results secured in 1906.

cent, and for the five Northern varieties, 49.1 per cent. With the average yield of the Northern corns, being 0.7 bushels less per acre, they have produced 8.2 per cent more ear to total plant than did the varieties from the South.

FACTORS AFFECTING PERIOD OF MATURITY.

With corn as with other plants, the number of days required for the growth of the plants from the sprouting of the seed to full maturity is governed, within narrow limits, by variety, soil, season, elevation, fertilization, date of planting and source of seed. Of the varieties grown in different portions of North Carolina, it usually requires from one hun-

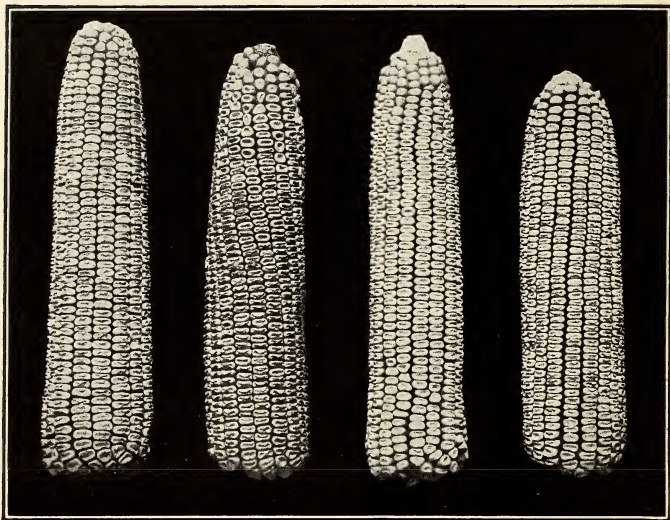


FIG. 8.—Type Ears of Varieties: (29) Leaming Yellow; (30) Kansas Sunflower; (31) Jones' Yellow Dent; and (32) Hildreth's Yellow Dent.

dred to one hundred and forty days to make a completed growth from planting.

Effect of Variety.—In the study of varieties of corn during the past few years many instances of differences in earliness in maturity of varieties, originated under the same conditions and sometimes by the same grower, have come under the observation of the writer. To some extent the originator or improver of a variety may select seed in such a manner as to have the variety within a few years mature at either an early, medium or late date. Jarvis' Improved, which was originated

TABLE II.—NUMBER OF DAYS REQUIRED FROM PLANTING TO TASELING AND MATURITY OF TWENTY-ONE VARIETIES OF CORN DURING SIX YEARS.¹

VARIETIES.	SOURCE OF SEED.	1903.		1904.		1905.		1906.		1907.		1908.		Average of 1903-1908.	
		Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.	Number Days to Tassel.	Number Days to Mature.
Biggs' Seven-ear	North Carolina	---	---	73	122	---	---	72	121	74	116	58	116	68.0	117.7
Hickory King	Tennessee	71	123	---	---	58	110	65	120	67	115	50	114	60.7	116.0
Cocke's Prolific	North Carolina	71	126	73	122	63	110	70	120	71	115	56	117	65.7	117.3
Mariboro Prolific	South Carolina	---	---	---	---	63	110	72	120	76	121	57	114	68.3	118.3
Boone County White	Indiana	62	121	64	115	53	104	65	113	66	111	55	105	60.8	111.5
Boone County White	Tennessee	64	121	68	115	58	104	68	113	69	111	55	116	62.0	109.7
Cocke's Prolific	Tennessee	71	126	73	122	63	110	---	---	73	119	---	---	64.0	113.3
Southern Beauty	North Carolina	---	---	---	---	---	---	71	121	69	115	56	117	65.3	117.7
Peele's Prolific	Tennessee	---	---	---	---	63	110	69	121	---	---	---	---	65.3	117.7
MacMackin's Gourdseed	Tennessee	---	---	73	126	63	113	68	120	72	119	57	114	66.0	117.7
Reid's Yellow Dent	Illinois	62	117	66	115	53	101	64	106	66	111	57	114	61.3	110.7
Iowa Silvermine	Georgia	59	117	63	114	53	97	61	106	61	106	52	101	58.2	106.8
Sanders' Improved	Georgia	71	126	73	126	63	110	74	121	74	120	59	121	69.0	120.7
Selection 77	Ohio	59	121	64	115	53	110	65	113	65	111	54	105	61.3	109.7
Weekley's Improved	South Carolina ²	69	124	73	122	63	110	72	123	75	121	57	119	68.2	119.8
Boone County Special	Indiana	---	---	64	114	53	104	68	113	67	117	56	105	63.7	109.7
Mosby's Prolific	Mississippi	75	126	73	126	70	113	---	---	79	127	56	120	---	---
Leaming Yellow	Ohio	59	117	60	114	53	97	57	106	59	102	48	98	56.0	105.7
Farmers' Favorite	North Carolina	---	---	---	---	---	---	68	116	74	120	53	106	65.0	114.0
Riley's Favorite	Illinois	59	117	61	114	53	101	59	106	62	106	51	105	57.5	108.2
Eureka	Virginia	---	---	---	---	63	110	73	121	---	---	56	116	57.3	105.7
Averages ³	---	63.5	120.7	66.5	117.2	56.5	104.4	65.5	112.7	66.8	111.4	54.4	110.1	63.5	113.2

¹All the varieties were planted as follows: On May 4 in 1903; on April 30 in 1904; on May 19 in 1905; on May 3 in 1906; on May 14 in 1907; and on June 9 in 1908.²Seed of Weekley's Improved for planting after 1904 came from the Fredell Test Farm, North Carolina.³These averages, except in the last two columns, are made up only of the results secured from the ten varieties which were tested continuously for the six years under consideration.⁴Average of results of 1906 and 1907 only.⁵Average of results of 1906 and 1908 only.

in the same section as Sharber's corn, matured, during the past two years, on an average, at the Station farm, four and one-half days earlier than the latter, when both were grown under identical conditions of soil, fertilization and cultivation. In the variety tests during 1903, 1904, 1905, 1906, 1907 and 1908, as seen by Tables II and III, Boone County White averaged four days later in maturing than did Riley's Favorite, originated in Indiana by the same grower. In comparing varieties from different sections of the country and originated on different soils, as great differences as twenty days have been found in date of maturity, but other factors than variety enter here to make these differences.



(33)

(34)

(35)

FIG. 9.—Type Ears of Varieties: (33) Jarvis' Improved; (34) Henry Grady; and (35) Fry's Improved.

Effect of Soil.—Other things being equal, soils made up of sand, partially or totally, when well drained, warm up much earlier in the spring than do soils containing much clay, because of their low specific heat. Soils which are open in their nature and normally contain small percentages of water may be plowed and planted to crops much earlier in the spring than those of a more compact nature and which possess a much higher content of moisture. Generally, the darker the phase of the soil and the less moisture it contains, the earlier it will warm in spring and the quicker crops will start growth when put out on it. Crops grown on soils of a sandy or sandy loam character will usually

TABLE III.—COMPARISON OF SOUTHERN AND NORTHWESTERN VARIETIES OF CORN FOR FIVE YEARS WITH REFERENCE TO NUMBER OF DAYS REQUIRED FOR TASSLING AND MATURING.

VARIETIES.	SOURCE OF SEED.	1903.		1904.		1905.		1906.		1907.		Average of Five Years.	
		Date of Tassling.	Date of Maturity.	Date of Tassling.	Date of Maturity.	Date of Tassling.	Date of Maturity.	Date of Tassling.	Date of Maturity.	Date of Tassling.	Date of Maturity.	Date of Tassling.	Date of Maturity.
Southern Varieties.													
Cocke's Prolific	North Carolina	July 14	Sept. 7	July 11	Aug. 29	July 21	Sept. 6	July 12	Aug. 31	July 24	Sept. 6	July 16	Sept. 4
Weekley's Improved	North Carolina	July 12	Sept. 5	July 11	Aug. 29	July 21	Sept. 6	July 14	Sept. 3	July 28	Sept. 12	July 17	Sept. 5
Sanders' Improved	Georgia	July 14	Sept. 7	July 11	Sept. 2	July 21	Sept. 6	July 16	Sept. 1	July 27	Sept. 11	July 18	Sept. 5
Cocke's Prolific	Tennessee	July 14	Sept. 7	July 11	Aug. 29	July 21	Sept. 6	-----	Aug. 31	July 26	Sept. 10	July 18	Sept. 5
Mosby's Prolific	Mississippi	July 19	Sept. 7	July 11	Sept. 2	July 28	Sept. 9	-----	Sept. 6	Aug. 1	Sept. 18	July 23	Sept. 8
Averages		July 15	Sept. 7	July 11	Aug. 31	July 22	Sept. 7	-----	Sept. 2	July 27	Sept. 11	July 18	Sept. 5
Northwestern Varieties.													
Iowa Silvermine	Illinois	July 2	Aug. 29	July 1	Aug. 21	July 5	Aug. 24	July 3	Aug. 17	July 14	Aug. 28	July 5	Aug. 24
Leaming Yellow	Ohio	July 2	Aug. 29	June 28	Aug. 21	July 5	Aug. 24	June 29	Aug. 17	July 12	Aug. 24	July 3	Aug. 23
Reid's Yellow Dent	Illinois	July 5	Aug. 29	July 4	Aug. 22	July 5	Aug. 28	July 6	Aug. 17	July 19	Sept. 2	July 8	Aug. 26
Riley's Favorite	Indiana	July 2	Aug. 29	June 29	Aug. 21	July 5	Aug. 28	July 1	Aug. 17	July 15	Aug. 28	July 4	Aug. 25
Boone County White	Indiana	July 5	Sept. 2	July 2	Aug. 22	July 11	Aug. 31	July 7	Aug. 24	July 19	Sept. 2	July 9	Aug. 29
Averages		July 3	Aug. 30	July 1	Aug. 21	July 6	Aug. 27	July 3	Aug. 18	July 16	Aug. 29	July 6	Aug. 25

¹ Average of the results of 1903, 1904, 1906 and 1907.

mature several days earlier than when planted on clay soils. Ordinarily, crops planted on coarse sandy soils require a less number of days to mature than when grown upon clay soils.

Effect of Season.—With all soils, the drier the season the earlier, within narrow limits, the corn is forced to maturity. Cool weather towards the latter part of the growth of the plant, especially if accompanied by dryness, will tend to hasten maturity, while warm, seasonable weather during the early stages of maturity will prolong the date of ripening.

The seasonal effect upon maturity of corn is strikingly brought out by the average results of ten varieties given at the bottom of Table II. It will be observed from these data that the varieties required on an average to mature eight more days in 1903 and four and one-half days in 1904 than in 1906, and seven more days in 1907 than in 1905, when the date of planting did not differ more than five days between 1903, 1904 and 1906, and between 1905 and 1907.

During an ordinary season the moisture condition of the soil is a very potent factor in determining not only the amount and rapidity of growth, but also in influencing to a certain extent the length of time required by crops to complete their development.

Effect of Elevation.—In going from the seacoast to the mountains it is observed that the awakening season grows later, and generally the growing period of plants is gradually shortened as the elevation above sea level increases. The retardation of plant growth due to this cause is usually between one-half and one day per hundred feet of ascent; hence the opening season at Jefferson, North Carolina, will usually be between fourteen and twenty-eight days later than at Beaufort, North Carolina, as there is about 2,800 feet difference in the elevation of these two towns. Other factors than elevation, such as soil and rainfall, may enter in to make a difference in the beginning and length of period of growth of various crops in different localities.

Effect of Latitude.—In a general way it may be assumed, other conditions remaining the same, that going north or south of a given locality one degree (approximately 70 miles) will make a difference in the opening of the season of three to four days, while going east or west of a given locality, without change of rainfall, soil type or elevation, will produce but little difference. Going south, it will be found that the season is earlier, while going north there will be noticed a delay in the awakening of all vegetation.

From what has been said above, it will be seen that increasing the latitude (going north) by one degree, other conditions being equal, retards the opening of the season by approximately the same length of time as an increase in elevation of 300 to 400 feet. This is largely the reason why the section around Jefferson, North Carolina, and other localities of a like altitude have a similar climate and grow about the same kind of crops as are produced in central New York, which is about seven degrees farther north. It will be noticed, in going from Beaufort to Jefferson, this State, a distance of about 300 miles, due largely to a difference in elevation, that about the same retardation in the starting of plant

growth in the spring is observed as would be in going from Beaufort to central New York, a distance of something like 550 miles. In going south it is usually found that the season is generally earlier by three to four days for each degree of decrease in latitude or reduction of 300 to 400 feet in elevation. For reasons given above, it has been observed that seed brought from Northern States or from the higher mountain regions, when sown in central or eastern North Carolina, grow more rapidly and the plants from them mature at an earlier date than do those



FIG. 10.—Type Ears of Varieties: (36) Wyatt's Improved Yellow; (37) Hastings' Prolific; (38) Marlboro Prolific; and (39) Cocke's Prolific (Tennessee).

from seed which are native to the warmer and lower portions of the State and of the South. It has been found, as shown in Table I, as an average of the results of five years' field experiments with five leading Southern and an equal number of Northwestern varieties of corn, that the seed from Illinois, Indiana and Ohio developed more rapidly than did the Southern-grown varieties. The average date of tasseling and maturity of those, seed of which came from the Northwest, were twelve days for tasseling and eleven days for maturity earlier than for the Southern varieties, when all were planted at the same date, on the same type of soil, at the Station farm, and received identical fertilization and cultivation. Varieties from the Northwest seem not only to be more precocious, but to suffer most from the effects of dry weather, as is shown

in Table I, by their average for 1903, being four bushels less than the average of the yield of the five Southern corns. At the Station farm during the first part of August of this year the drought did considerable damage to all crops, but seems to have affected most severely those varieties brought from higher latitudes, as the differences of the averages of yields of the years 1904, 1905, 1906 and 1907 did not exceed one-half bushel for the varieties taken together from the two different sections. The entire crop during the season of 1907 was greatly reduced in yield as the result of drought, but was much more favorable to the earlier-maturing varieties, as a good rain fell just before the tasseling of these Northwestern varieties. It was quite dry before, during and after the tasseling stage of the Southern varieties. It has been found in studying varieties that usually those maturing latest are the ones seed of which have been brought into North Carolina from States located to the south of us. Those varieties originated farther south than 34 degrees north latitude have not been found generally to be among the best yielders for the State. Many of them, especially those from the more remote Southern localities and those of the one-ear type, have shown up poorly in the Station tests. Most of the late-maturing varieties originated within North Carolina have come from the eastern half of the State.

It might be stated in this connection that when varieties of corn from the Northern and Northwestern States are brought to the eastern or Piedmont sections of North Carolina and grown for a number of years the period required for their development is gradually lengthened as they become more and more acclimatized. As an illustration of this fact it has been found that Boone County White corn acclimatized to Tennessee has required 3.6 days more to complete its growth at the Station farm, as an average of three years' tests, than seed of the same variety secured from the originator in Indiana. With varieties brought from the extreme South the reverse takes place, as the time necessary to complete their growth is gradually shortened during the period of acclimatization. Varieties taken from the Coastal Plain to the mountains behave about the same as varieties brought from the South into the State, while those taken from higher altitudes and carried towards the coast conduct themselves quite similar to those seed of which have come from higher latitudes.

Effect of Fertilization.—Fertilization of corn and other crops, either with ordinary applications of commercial fertilizer or barnyard manure, has been found to hasten the maturity of the plants on poor upland soils. In the variety test last year, embracing a study of sixty-eight varieties, it was found that the corn in the sets receiving a liberal application of cow manure and fertilizer tasseled three days earlier than did the same varieties in other sets which received 300 pounds per acre of a fertilizer mixture analyzing 7 per cent available phosphoric acid, 3 per cent nitrogen and 1.5 per cent potash. With all these varieties there were but two (Brake's and Hickory King) which were exceptions to the general average and matured later on the highly manured plats. Even in the case of these the differences were quite small. It has also been observed that, as the whole plant development is accelerated, the period between tasseling and maturity is shortened. Also, in the regular fertilizer plats it

has been observed for some years that the corn on those plats which were unfertilized tasseled and matured at a somewhat later date than did the corn on plats in the same series receiving an application of commercial fertilizer and worked in the same way.

Effect of Date of Planting.—Late-planted corn will usually reach the tasseling stage in a much shorter time than that which was planted early. From a study of the averages given at the bottom of Table II it will be seen that the ten varieties, results from which averages were taken, when planted during 1903, 1904 and 1906, at about the same date—the



(40) (41) (42) (43)
FIG. 11.—Type Ears of Varieties: (40) Hickory King (Tennessee); (41) American Queen;
(42) Parker's Cocke's Prolific; and (43) Bradbury's Improved.

average of the three years being May 2—they required for these years an average of 10.8 days longer to arrive at the tasseling stage than it did for them in 1908, when the planting was delayed until June 9. During 1905 and 1907, with plantings made on May 19 and 14, respectively, the varieties prolonged their growth between planting and tasseling 7.3 days beyond that required for the same development in 1908. The number of days required to mature seems to be slightly decreased by late planting. In 1905, as shown by the results in Table II, the length of the period required to bring all the varieties to maturity was shorter than in any of the other years used in the study. This seems to

have been due largely, if not entirely, to the effects of cold east winds prevailing during August of this year, and which brought all the varieties to premature maturity.

SOME LARGELY CONTROLLABLE FACTORS AFFECTING YIELD.

To secure large yields in any locality it is essential that good seed, a productive soil and proper tillage be supplied. By the neglect of any one of these factors it is absolutely impossible to secure a maximum yield, as this is determined, not by the most favorable factors, but by those essential ones present in the least-suited form for normal plant growth, just as the strength of a chain is gauged, not by its strongest, but by its weakest link. Some of the controllable factors involved in these three essentials will be discussed below. That portion of our subject pertaining to the soil, its fertilization and cultivation will be deferred for a subsequent bulletin, and will be taken up in discussing the results of fertilizer experiments which have been conducted on the Station farm during the past few years. Only those phases of the subject pertaining to seed will be touched on which are not discussed elsewhere in this Bulletin. The farmer who gets most out of, or the one who suffers least from uncontrollable factors, such as lack of sufficient temperature and rainfall, is the one who regulates the controllable factors most intelligently.

Earliness in Maturity.—Except for the more elevated portions of the mountain region, or under circumstances in the other portions of North Carolina necessitating late planting, those varieties of corn producing the largest yields have been found to be those which mature at a medium to late date. Under certain conditions the early maturing varieties may be the largest yielders, but this is where the length of time for growth for some reason is not sufficiently long from planting to frost to mature those which require more time to complete their development; hence, when planted under these conditions, would suffer material reduction in yield by being caught by frost.

It can generally be assumed that varieties, not only of corn, but other crops, which mature early will not be large yielders, for earliness and high yield are antagonistic characteristics. With many crops, however, earliness is more essential than heavy yields; especially is this so with trucking crops, for if they do not reach maturity early in the season the best prices are not obtained. Where for any reason the season for growth is short, the best of the early varieties will give the largest yields under the conditions, but the yield will be smaller generally than would have been produced by the best of the medium and late maturing varieties had the season been sufficiently long for their full development.

Seed Selection.—The more intelligently and persistently field selection of seed is carried on, the larger the yield of corn from such seed will be. Within limits, the number of ears borne by any variety of corn is within the power of any corn grower to control, if proper methods of seed selection are used to supplement good soil and cultivation. One of the best yielding varieties grown in this State and tested is Biggs' Seven-ear; it is also the most prolific variety thus far found. Prolificacy is a largely controllable characteristic of the corn plant, which is

associated with high yield, as is evidenced by most of our best yielders being of this type. On account of lack of appreciation of the possibilities for the improvement of yields by the use of good seed, selected from the field in the best manner, many farmers have not secured near the production per acre which their farms are capable of producing with the cultivation and fertilization which is usually bestowed. The matter of distancing rows and plants in the row, and of the effects of removing suckers from the plants, is also reserved for discussion in subsequent bulletins. It might be interesting to note here that the tendency to produce suckers seems to be largely a varietal characteristic.



(44)

(45)

(46)

FIG. 12.—Type Ears of Varieties: (44) Boone County White (Tennessee); (45) Boone County White (Indiana); and (46) MacMackin's Gourdseed.

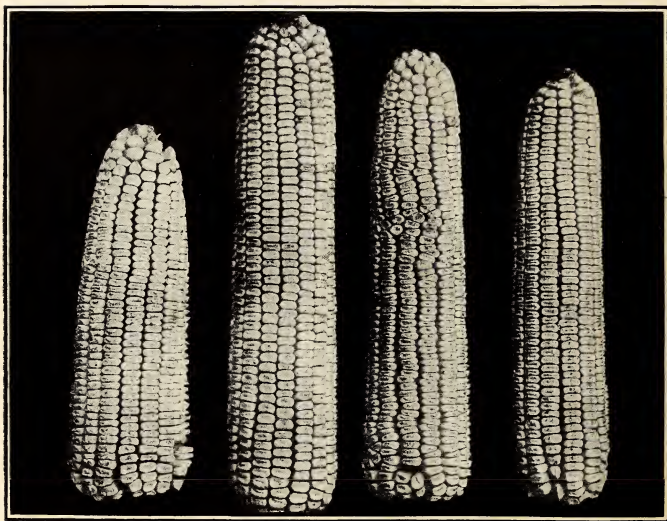
METHODS OF IMPROVEMENT.

At present there are three methods in common practice for the improvement of corn by seed selection, viz.: (1) importation or buying of improved seed; (2) field selection of the best home-grown seed, and (3) home field selection and growing of corn for seed purposes in an isolated field.

IMPORTATION OF SEED.

Under no circumstances should farmers depend each year upon importation for seed, as corn brought from a distance (where soil and climatic

conditions are different) seldom yields satisfactory results until it has become thoroughly acclimatized, which usually requires from two to three years. The force of this statement is amply illustrated in our experience with the best varieties of Western and Northwestern corn. None of these have done extra well under North Carolina conditions the first year after importation, although they are among the most prolific ones grown in the principal corn-growing belt of the country. This



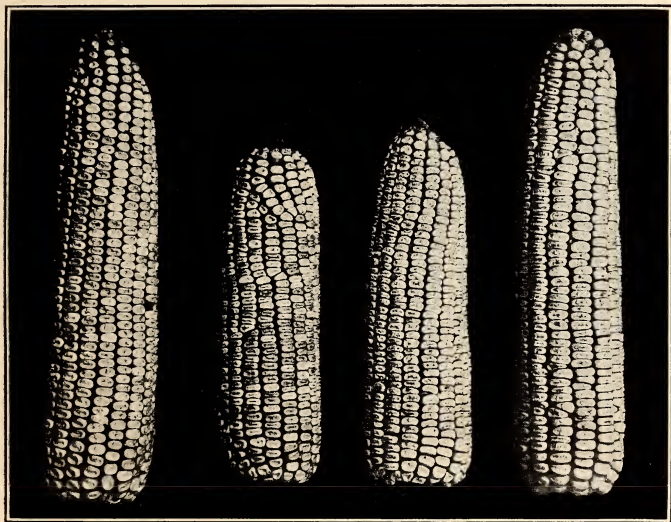
(47) (48) (49) (50)
FIG. 13.—Type Ears of Varieties: (47) Southern Beauty; (48) Eureka; (49) Mosby's Prolific; and (50) Sanders' Improved.

further emphasizes the need in all variety tests of as complete knowledge as possible of the conditions under which the parent plants were grown. Especially should the locations be known from whence all seed come, before one can properly interpret varietal results; for, if not acclimatized, suppressed yield may be expected from this cause.

The advantage of imported seed is that the farmer is frequently enabled to begin improvement where some careful grower or skilled plant breeder has left off. It is here as with animals; for, if it is desired to breed milk cows, it is not best to go back to the "scrub" to begin selecting the desirable animals, but rather to begin with some of the best of the recognized milk breeds, like the Jersey, Guernsey, etc., and with these continue the improvement by breeding and selection.

Buying Seed.

In buying seed it is usually safest to secure seed in small quantities first, and from as near home as possible, other things being equal, and give them a trial before making extensive planting of the variety. This can be done, as some of the best yielders for North Carolina soils thus far found are those which have been originated in this and adjoining States. If a neighbor has better field-selected corn than you have, by all means secure some of his seed, as it will be found generally that his corn will do better in that particular neighborhood than corn bought at



(51)

(52)

(53)

(54)

FIG. 14.—Type Ears of Varieties: (51) Reid's Yellow Dent; (52) Riley's Favorite; (53) Iowa Silvermine; and (54) Selection 77.

a distance. It is suited to the local conditions, as is evidenced by its superior yielding qualities. Farmers, in purchasing seed corn at a distance, should require the dealers to ship it on the ear and supply a statement as to where it was grown. This is essential, for, as pointed out above, if the corn was grown under greatly different soil and climatic conditions from those under which it is to grow, the seed will seldom prove satisfactory for at least the first two or three years, although they may be of strong vitality, good quality and come from an excellent variety, produced by a careful, conscientious grower. Another advantage of buying seed on the ear is that when it comes if it is not satis-

factory it may be returned to the shipper, or if only a few ears are unsatisfactory they can be easily thrown out before shelling. It is best, in shelling seed corn, that each ear be shelled separately into a pan or bucket before putting with others, so that ears with undesirable characteristics may most easily be discarded.

It is not always cheapest to buy the seed corn that can be purchased for the least money. In the tests of the Station, differences of five to ten bushels of shelled corn per acre between the yield of different varieties are of no uncommon occurrence. Now, assuming an average difference in yield of seven bushels per acre between two varieties, and placing seed of the poor-yielding one at 70 cents and seed of the best field-selected one at \$2.10 per bushel, and assuming that a bushel of corn will plant seven acres, it will make the seed of land planted to the poorer grade cost 10 cents, while the planting to seed of the better variety will cost 30 cents per acre. Now, deducting the difference in the cost of seed for planting an acre to each of these varieties, a gain of \$4.70 in favor of the use of the better seed is shown when the excessive yield of this is calculated simply at the market price of ordinary corn.

On the other hand, because a variety is advertised in extravagant superlatives and quoted at an advanced price, it is not always a guarantee of its worth. Hence, the best method to pursue in purchasing seed corn is to buy only from the most reliable parties and have it shipped on the cob, so as to enable the buyer to see just what he is getting. This precaution is advised because it is a well-established fact that many seedsmen buy whole surplus crops of corn and, without a particle of selection, other than removing rotten ears, shell and screen it and place it upon the market, after thoroughly advertising it, at a price many times the market price of ordinary corn, and often it is no better and sometimes decidedly inferior.

In buying seed corn on the ear do not expect too much, however, for it should be remembered that there are only a few prize ears in any field, and it would cost many dollars per bushel to get these out.

Acclimatization of Corn.

Other things being equal, it is not wise generally to import corn from a distance, especially a different latitude, because it will not, as a general rule, yield satisfactory returns until it has become thoroughly acclimatized, which usually requires from two to three or more years. We have had many striking instances of this fact in our tests of varieties of corn brought from the Northwestern States. None of these varieties have done very well with us, although they are the most prolific ones in the Northwest. This is the reason that it is urged, in another part of this Bulletin, that the history of all seed corn purchased be ascertained from the dealer. Neither is it prudent to buy seed corn that was grown in the extreme South, for it, being accustomed to a longer growing period than we have in North Carolina, will be liable to be caught by frost and thereby give a diminished yield of immature grain, especially if cool weather comes early in the fall. The small yield of the Northwestern corns, on the other hand, being accustomed to a shorter growing period than we have, is led to mature at an earlier period than is conducive to the largest yields in our climate.



(1)

(2)

(3)

FIG. 15.—Poor and Well-shaped Ears: (1) Too much space between grain-rows and poorly filled at tip; (2) Ear undersized; and (3) Well-shaped ear.

FIELD SELECTION OF SEED.

The proper place to select seed corn is in the field, at or just before gathering time, and select from stalks that have the most shelled corn per stalk, as such seed will tend to produce an increased yield in the next year's crop. Any method of seed selection that does not take the plant as a whole into consideration is not going to lead to the best results; for the stalk and leaves, which are the manufactory of the plant, determine to a considerable extent the size and quality of the ears. In all our results it has been observed that those varieties which have generally been the best yielders are those which produce more than one ear per stalk. Ears of medium length and size are preferable to the long and large ones, because the latter were generally either produced on stalks that bore but one ear, or else on stalks that grew on some fertile spot in the field, either of which seed do not tend to promote the greatest yields when planted. Seed from corn grown on average land will do better planted on land of medium fertility than when seed from corn grown on rich land is used, for the same reason that stock accustomed to poor conditions will do better on an inferior pasture than stock accustomed to more favorable surroundings.

The selection should not be turned over to the hired man, but should receive the best efforts of the farmer himself, as it is sure that time expended in this work will prove as profitable, if not more so, than any other work done on the farm. By continually selecting and planting corn possessing certain desirable characteristics, such as production of two good ears per stalk, it will be found, as the selection goes on from year to year, that these desirable qualities have each year become more thoroughly fixed.

It should be constantly kept in mind that on every farm changes, beneficial or detrimental, are continually taking place, as it is an inherent tendency of all plants to vary more or less and retrograde or revert to a less productive state if intelligent and rigid selection is not persistently kept up.

In making selections in the field, at least three to four times as much corn should be gathered as it is desired for seed purposes the following year, so that further and more careful selection can be made after the ears have been taken to the barn and when a leisure time presents itself. In the final selection the ears should be arranged conveniently on the barn floor or ground, and with an ear of the type desired in mind or in hand, go over the lot and remove all undesirable ones. The seed thus selected should be transferred to a box or barrel and covered with wire gauze or something else that will permit of thorough ventilation and keep out rats and mice. Store the barrel or box in some dry place and let remain until the seed are wanted for planting.

UNIFORMITY IN HEIGHT OF EARS.

If all the ears in a field are of approximately uniform height, there is greater probability of complete fertilization and filling of all the grains of the ears than would be the case if some of the ears were high up on the stalks, while others were comparatively near the ground. An

extremely high ear tends to late maturity, while one very near the ground tends to ripen early, hence will not make, as a general rule, a very large growth. For the ears in a field to be completely fertilized or pollinated, the silks of the ears should be ready to receive the falling pollen grains (dust-like particles) from the tassels as soon as they begin to be disseminated by the wind.

BARN SELECTION.

It is a common practice with many farmers of North Carolina to make seed-corn selection from the crib in the spring, just before planting time, when the quantity is small and the quality inferior. This method



FIG. 16.—Type Kernels of Varieties: (1) Cocke's Prolific; (2) Weekley's Improved; (3) Shellem's Prolific; (4) Biggs' Seven-ear; (5) Hickory King; (6) Wilson's Success; (7) Thomas' Improved; (8) Farmers' Favorite; (9) Butler's Prolific; (10) Square Deal; and (11) Brake's.

yields better results than no selection at all, but is far inferior to field selection, where the performance record of each stalk may be given consideration.

In barn selection it is usually the larger ears that are chosen for seed purposes, and these are not generally, as pointed out above, the best ones for seed. We have in this State, by our barn method of seed-corn selection, been unconsciously selecting, growing and perpetuating types of corn of low prolificacy.

RESULT OF PROPER SEED SELECTION.

By careful seed selection the yield for North Carolina could easily be increased two bushels of shelled corn per acre, which would be worth about four million dollars per year clear to the farmers of the State when corn is selling for 75 cents per bushel. By adding one kernel per ear to the present yield, through the use of better methods of seed selection, from \$75,000 to \$100,000 annual increase would result in net receipts for the corn crop of the State. These are exceedingly low estimates of what might be done by the use of proper methods of seed selection, for the writer, as well as workers in other States, have found that from five to ten bushels of shelled corn more are yielded per acre from well-selected seed than from those selected by a less intelligent method.

FIELD SELECTION AND GROWTH OF SEED IN AN ISOLATED FIELD.

By carefully selecting a limited number of the very best obtainable seed ears from the field in the fall and planting them in a field separated from any other corn, something like 500 to 600 yards, to prevent crossing by the pollen being carried by the wind, much better and quicker results may be secured than where simple field selection from the general crop alone is practiced, *i. e.*, if the breeding plat is properly cared for. This plat should be tolerably fertile (equal at least to the lands on which the general crop is to be grown), for poverty of soil is very conducive to reversion, thereby losing in one year's growth on a poor soil much of what has been gained by a number of years of rigid selection. The rows in the breeding plat should be of such length that they will require only about three-quarters of an ear per row; and, in planting, each row should receive its individual ear, so that the performance record in yield of each seed ear can be seen, and if not satisfactory the whole row may be rejected for seed purposes. After planting as many rows as desired from the selected ears, a composite sample should then be made of the quantity of each ear left over, and a border of several rows planted entirely around the breeding plat to still further prevent the possibility of wind pollination from outside cornfields. The land on which this plat is to be located should be given deep and thorough preparation. The subsequent cultivations of the corn should be every ten to twelve days, with a cultivator with smaller hoes on, rather deep early in the season, but becoming shallower and with the larger hoes on as the season advances and the root system extends towards the middle of the row and nearer the surface. Especially is this important on upland soil, where conservation of moisture plays such an important part in yield. When the corn in the breeding plat has attained the tasseling stage the tassels from all barren stalks should be carefully removed just as they are emerging from the rolls of the last leaves. The tassel is the male part of the corn plant, while the silk is the female part. When the stalk is barren or bears only male organs the tassel is frequently above the average in size, strength and vigor, as all the vital forces of such a plant have been expended on this single organ of reproduction; hence, when an ovule or embryonic kernel, through the silk, is fertilized or pollinated by the yellow dust-like pollen from a barren stalk, it will, when planted,

have a strong tendency, inherited through its male parent, to produce a barren or poor yielding stalk. The tassels should also be removed from all weak, diseased and otherwise stunted plants, for the same reason we would not use a "scrubby," stunted bull in a herd of cows if we cared anything for the future improvement of the stock. It has been demonstrated time and again by carefully conducted experiments that by selection from poor plants the yield of grain will not only be materially reduced, but will also be of an inferior quality. The writer has during the past six or eight summers visited a number of cornfields in different



FIG. 17.—Type Kernels of Varieties: (12) Holt's Strawberry; (13) Mosby's Prolific; (14) Sanders' Improved; (15) Southern Beauty; (16) Eureka; (17) Hastings' Prolific; (18) Selection 77; (19) Iowa Silvermine; (20) Boone County White; (21) Reid's Yellow Dent; (22) Riley's Favorite; and (23) Leaming Yellow.

parts of the State, and has found but few fields that contained less than ten per cent of barren stalks, which means that from every ten acres in cultivation a loss of the yield of one acre from nonproductive stalks is generally sustained. It must not be overlooked that the secret in successful corn growing consists in having a good stand and in having each stalk bear at least one or two good-sized ears, as it costs just as much to cultivate nonproductive stalks or land without stalks as it does prolific ones and a good stand. The number of barren stalks in our fields should not, under average conditions of fertilization, weather and cultivation, ever reach over three to five per cent.

CHARACTERISTICS TO CONSIDER IN SEED SELECTION.

As total yield of shelled corn per stalk is the principal consideration in the production of corn, the following characteristics correlated with large yield will be taken up somewhat in detail for consideration:

PERCENTAGE OF GRAIN.

Although it is essential for any variety to possess the characteristic of producing a high percentage of grain to ear for it to attain its maximum yielding capacity, yet, as other factors, such as prolificacy, size of ears, source of seed, etc., enter, the largest yields need not necessarily be expected from those varieties possessing the highest percentage of grain. As a matter of fact, the largest yields by varieties tested at the Station farm during the past five years have been secured from those which produce a medium percentage of grain; but this is not because this is an unessential of the highest possible yields, but rather due to the fact that varieties possessing the highest percentages of grain have been bred and selected largely for this quality alone, while other characteristics that might have contributed to the yields were seemingly left out of consideration to a large extent in the establishment of these varieties.

The best yielding varieties have been found to bear ears which shell on an average of eighty to eighty-seven per cent grain. With the same variety there is a seasonal variation of a fraction of a per cent to two to four per cent, or even more.

Of the varieties thus far tested, Dodson's Prolific Shoepeg, Hickory King, Sanders' Improved, Craig's Prolific Strawberry and Craig's Prolific White have been found to possess the highest percentage of grain to cob. One hundred pounds of the ears of each of these shell from eighty-five to ninety pounds of grain.

HEIGHT OF EARS AND STALKS.

The best yielding varieties when grown at the Station have been found to be those which have a medium to tall stalk and which bear their ears at a medium height. The varieties possessing the lowest stalks and ears are those which have come from the corn-growing States of the Northwest. Cocke's Prolific, Mosby's Prolific, MacMackin's Gourdseed, Sanders' Improved and Eureka have shown up as some of the tallest growers and are varieties which bear the ears at an average height, a little less than one-half the height of the stalks.

NUMBER EARS PER STALK.

In variety tests on the Station farm during the past six years, as it has been found to be a pretty general rule that those which have averaged the largest yields of grain per acre were those possessing a decidedly strong tendency to produce more than one ear per stalk, it would seem to be safe to infer that the prolificacy of stalks in ears should be given consideration in selecting seed corn in the field. In the Station tests it has been found that Sanders' Improved, a fairly prolific variety, has yielded as an average of five years 6.8 bushels more of shelled corn per acre than Holt's Strawberry, a good one-eared variety; while Biggs'

Seven-ear, another prolific variety, has outyielded Holt's Strawberry 4.4 bushels as an average of three years' tests. Ordinarily, for the better grade of improved farming lands of the State, it is not felt that it would be wise to select seed from stalks bearing more than two ears. It is believed that the richer the land on which the corn is to be planted the greater the prolificacy in ears that may be selected with profit. On the poorer grades of land it is suggested that, until its yielding capacity has been increased, the best one-eared varieties be grown. Too great a prolificacy of corn to be planted on poor land may be a positive detriment



FIG. 18.—Type Kernels of Varieties: (24) Kansas Sunflower; (25) Jones' Yellow Dent; (26) Hildreth's Yellow Dent; (27) Wyatt's Improved Yellow; (28) Sharber's; (29) Hickory King (Virginia); (30) Culpepper's Extra Prolific; (31) Goodman's Prolific; (32) Columbian Beauty; (33) Jones' White; (34) Wright's Improved; and (35) Dodson's Prolific Shoepeg.

to yield. The tendency of such seed will be to produce a large number of ears; and as the limited supply of available plant food contained in the soil will run quite low towards the latter part of the growth of the plants, there will usually be a large number of shoots and nubbins produced and very few ears; while on the other hand a one-eared variety might have given fairly good-sized ears under the conditions; certainly it would in all probability have done better. It might be stated in this connection that, where these conditions of soil obtain, it is thought that time might be put to better advantage in growing on it soil-improving

crops, such as cowpeas and clover, and defer planting it to corn until it has been considerably improved in producing capacity. It is not felt that corn can be raised profitably on very poor land.

WHICH OF TWO EARS TO SELECT.

In the selection of seed corn from stalks bearing two or more ears per stalk the selections should be made from those stalks that have the ears of a uniformly convenient height for gathering and of those ears on the stalks that possess the greatest number of desirable characteristics. Most investigators in this country who have made careful field tests and kept accurate records with this cereal are pretty uniformly of the opinion that the top ear, being usually the largest, best-shaped and matured, is the one, as a general rule, to be preferred for seed purposes. However, with present knowledge on the subject, it will be well to select for seed all the ears on stalks bearing two ears per stalk, if the ears are well shaped and thoroughly matured and possess kernels of proper shape, color and vitality. For practical purposes it is felt quite strongly that this procedure will likely prove the most rational. It must be kept in mind that if it is wished to produce a variety that will bear more than one ear per stalk, selection should be made in the field each fall from stalks bearing two or more ears. What is meant by a two-eared variety of corn is, or should be, that when it is grown under the same conditions as other varieties, such as Holt's Strawberry, Southern Beauty, or Eureka, it will have decidedly more stalks bearing two ears than these one-eared varieties. Of course, other factors besides seed selection play an important part in determining the yield of any variety of corn. They are fertility and physical condition of the soil, season, cultivation, etc. Notwithstanding these facts, some seedsmen advertise that they have certain varieties of corn that will bear two, three, four, five and even six and seven ears, as the case may be, per stalk, implying, if not stating positively, that the exploited varieties with euphonious and "catchy" names will do these wonderful and impossible things regardless of poverty of the soil and unfavorable soil and seasonal conditions. It is often wise to let your neighbor do the buying from the man that claims too much, and do your own purchasing from one that claims less and supplies seed that do more.

LARGE VERSUS SMALL EARS.

Although, taking everything into consideration, where corn is gathered by hand in the ordinary way, it will usually be a little easier and slightly cheaper to gather and handle the same acreage of large-eared corn than of corn with smaller ears, when the yield of shelled corn per acre for both are the same; yet, quite frequently, from a financial standpoint, it will be better for the farmer to use seed of a variety possessing a relatively small ear, because of the greatly increased yield of grain per acre that would result from the use of such seed. Within reasonable limits, it should not be so much the size of the ears that should govern in the selection of a variety for seed purposes as the persistency of the seed of the variety to withstand adverse conditions and to produce large yields of shelled corn per stalk, and hence per acre. However, in selecting

within the same variety it will usually be advisable to choose for seed those ears, other characteristics being equal, that are of the average or slightly above the average in size for the variety.

The size of the ear of a variety is not determined solely by heredity, but is greatly influenced by climate, season, soil, fertilization, cultivation, etc.; for the more favorable these conditions are for the growth of the plants, the larger will the ears produced be at maturity; and the more unfavorable these conditions are, the smaller they will grow. In other words, if seed of the same variety were planted during the same year



FIG. 19.—Type Kernels of Varieties: (36) Cleckler's Improved; (37) Bradbury's Improved; (38) Fry's Improved; (39) Cooper's Improved; (40) MacMackin's Gourdseed; (41) Pool's; (42) Harris' Improved; (43) Peele's Prolific; (44) Williams'; (45) Fredonia's Pride; (46) Cleveland's Pure White; (47) Jackson's Whitecap Prolific; (48) Krimminger's Improved; (49) Whelchel's Dent; (50) Osborne; (51) McAuley's White Dent; (52) Henry Grady; and (53) Horsetooth.

on both rich bottom and ordinary upland soils, it would be found at maturity, with a favorable season, that the corn grown in the bottom had not only produced a larger yield and greater number of ears per stalk, but had also borne considerably larger ears, and it would generally be easy for one who is at all familiar with ear types of different varieties to determine by general appearances whether a given ear had been produced on rich land or not.

It will be better to use seed of a variety having medium small ears with poorly shaped kernels in preference to one with large, well-shaped

ears possessing well-formed kernels, if the former produces, under the same conditions of season, soil and cultivation, greatly increased yields over the latter, notwithstanding the fact that it may be a little less expensive to house the latter, because the net profit resulting from the former would be much greater.

By using a variety with a strongly fixed prepotency to high yield of shelled corn per stalk, the great desideratum, after all, the size and shape of the ear and its kernels, may be materially improved within a few years, through careful seed selection, with a resulting tendency to further increased yields over the original stock. It should be borne in mind clearly, however, that by developing better-shaped ears and kernels of any variety, through seed selection, persistently practiced through a number of years, that only two of the many characters that contribute to high yields are improved. The greatest underlying cause of high yields, outside of environment, is a reasonable prolificacy.

STALKS.

The kind of stalk from which to make selections is one possessing a tolerably large circumference at the base and gradually tapering towards the top, as this is the type that stands drought best, and is not as apt to be blown down as high, slender ones. In selection, weight should be attached to good root and leaf development of the mother parent, as all nourishment and growth are largely dependent upon the thoroughness with which these two organs do their work. Poor root or leaf development is indicative of meager growth and small, poorly-developed production. All selections should be made from perfectly healthy plants.

EARS.

In selecting seed corn, care should be given to the following characteristics of the ear: position on stalk, kind of shank, shape and color of grain and cob, size of cob, filling out of butts and tips, number of and distance between rows of kernels, and length and circumference. The percentage of ear to total plant usually varies from forty to sixty per cent, with an average of about fifty per cent, when the corn is grown under fairly favorable conditions. The smaller the yield, the smaller the percentage of ear to stalk.

Position on Stalk.—If all ears in a field are of approximately uniform height, there is greater probability of complete fertilization of all the grains of the ears than would be the case if some of the ears were high up on the stalks, while others were comparatively near the ground. An extremely high ear tends to late maturity, while one very near the ground tends to ripen extra early; hence the stalks on which such ears are borne will not make, as a general rule, a very large growth. For the ears in a field to be completely fertilized or pollinated, the silks of the ears should be ready to receive the pollen of the tassels as soon as it is given off. On the same plant the silks usually make their appearance in four to five days after the tassel.

The position of ear on the stalk should be at a medium height, for two reasons: (1) because the stalk will be less liable to be blown down, as the ears will have less leverage, thereby averting the injury caused by



FIG. 20.—Type of Cobs: At left, ear has too large cob and kernels are too shallow; at right, well-formed ear with medium size cob, kernels are deep and wedge-shape; at top, kernels not of shape to fill well space between grain rows; at bottom, cob too small and kernels too shallow and round.

lying on the ground, and (2) because, if at a convenient height, it may be gathered with a great deal more ease and at considerable less expense, because the work can be done more rapidly.

Shank.—This should be of sufficient size and strength to hold the ear well and in a rather drooping position, so that rain will be shed and hence prevented from running into the ear and causing the grain to rot, as would often be the case if the ear were held in an upright position, especially if the end of the ear was not covered well by shuck.

Shape.—The cylindrical ear (Fig. 15, 3) is the best type, as it is the one that generally yields the highest percentage of grain to cob and the largest total amount of shelled corn per acre. The rows of kernels should run parallel the full length of the cob, without change in shape or diminution in size, or, if so, but very slightly. If the ears are tapering towards the tip, there is a suppression of yield, due to one or both of two causes, viz.: (1) diminished size of kernels at the tips; (2) dropping of rows of kernels an inch or so from the tip end.

Color.—Yellow corn should have a deep-red cob, while white corn should possess a white one, and any variation from these types is usually indicative of crossing varieties. The market price of meal or grits made from white corn with red cobs is generally lower, because the particles of the red cobs getting into the corn and being ground in with meal give it a reddish and unattractive cast.

Size of Cob.—A medium-sized cob is the best, because it usually yields the largest proportion of corn to cob. If the cob is small, of necessity the number of grain rows is restricted, and when large the proportion of corn to cob is reduced. The best size cob is shown at right in Fig. 20; the ear at left is too large, while the one at bottom is too small.

Length and Circumference.—The length to circumference should be about as 4 to 3, i. e., if the ear is 8 inches long its circumference should be approximately 6 inches, when measured about one-third the way from the butt to the tip, in order to produce the largest yield. Too large circumference usually indicates small, narrow kernels, of low vitality and poor feeding value.

Filling-out of Butts and Tips.—The more perfectly ears are filled at butts and tips, usually the larger the percentage yield of corn. It is possible, by rigid selection of ears filled compactly at butts and tips, to increase materially within a few years the annual yield over corn in which no consideration is given to these characteristics. In Fig. 21 is shown poorly and well tipped ears.

Number of and Distance Between Rows of Kernels.—The number of rows to the ear should be comparatively large and the distance between them very small to secure the highest percentage yields. Wide *sulci*, or distance between rows, indicate reversion to an inferior type that it will not justify the farmer of to-day to grow. In Fig. 15 is strikingly shown the differences in the solid setting of corn on (1) and (3). In (3) there is little or no space between the rows, while in (1) there is considerable.

KERNELS.

The corn kernel may be divided into four parts: (a) the hull or outer layer; (b) the hard, flinty portion next to the hull and lying principally

at the sides; (c) the white, floury portion occupying the crown, and (d) the germ or chit, which is situated on the side of the kernel, facing the tip of the ear. The hard, horny portion contains the larger proportion of the protein (flesh-forming material), while the white, floury part of the crown is rich in carbohydrates (which is the fattening and heat-producing portion of the grain, mainly starch), and the germ carries a greater part of the oil and is also rich in protein. In making seed selections for high percentage yields the kernels should be of medium wedge shape, but not too long and sharp, for such a form not only "wastes space at the cob and restricts the size of the germ," but indicates inferior



FIG. 21.—Well and poorly filled ears at tips.

quality and low vitality. The wedge-shaped kernel is the one that fills more compactly than any other the space between the grain rows. If the kernels are of fairly good shape, the percentage of grain of the ear should range from eighty to ninety per cent. The kernels having thin tips generally contain relatively low percentages of oil and protein and high contents of starch, and usually possess low vitality. The best shape is a plump tip, of about the same thickness as the upper portion of the kernel.

In Fig. 20 are shown good and bad forms of kernels. The kernels on ear at right are of the best form, while those on all the other ears have some defects. Also, in Fig. 22 are shown fairly well-shaped kernels, which possess good germ development.

VITALITY OF SEED.

The vitality of any seed is largely governed by their stage of maturity when gathered, by the vigor of the parent plant, and by the care used in curing and storing them after harvest. As a general rule, with the same variety, the larger the seed, not only of corn, but all crops, the larger the amount of reserve plant food, and the higher the percentage of germination, and hence the better the stand. Low germination, resulting in a poor stand, is often one of the most potent causes for small yields. Large, plump seed are generally grown on strong, healthy plants. If possible, the seed corn should be gotten together and its germination thoroughly tested before planting time arrives. This can be done, after nubbing the corn, by taking three or four grains from different portions of the ears, putting them in moist sand in a plate, box or some other receptacle and placing in a warm place. The space in which the seed from each ear are placed should be marked in some way to correspond with the ear from which they were taken, and should be kept moist all the time, but not soaking wet. All the seed corn might be tested in this way with profit, and all those ears that showed a germination less than ninety-five per cent should be discarded. If the farmer cannot do this work himself, then he might interest his boys in it and let them do it. They will in all probability take great interest in this work, which may be done at night if necessary. This precaution is highly important, for, as a general rule, replants never amount to much, especially in the Piedmont and mountain sections of the State.

NUBBING EARS.

Carefully conducted experiments have demonstrated that it is advisable to nub corn before planting, for it has been found that, when seed from the tips and butts of ears are placed in one plat and by the side of it another is planted in kernels from the centers of the same ears, there is a larger percentage of dwarfed and barren stalks on the plat planted in tip and butt kernels than from the other, and hence less yield of shelled corn per acre. As both plats were planted on the same type of soil and treated in the same way by fertilization and cultivation, it is strongly probable that the decreased yield of the plat sown in butt and tip grains was due to the seed, as all other conditions were as nearly identical for both as it was possible to secure.

WHITE VERSUS YELLOW-EARED VARIETIES.

The Station, in its experiments, has secured higher yields of shelled corn per acre from the white than from the yellow varieties of corn. This greater yield may be due to the fact that the Southern people, being partial, as a general rule, to white corns, have improved them more than they have the yellow varieties. From the standpoint of chemical composition, the yellow corns are no richer in feeding value than the white ones, which fact is contrary to a common belief prevalent in this and other States. The only difference in the two is that there is a small amount of coloring matter present in the kernels of the yellow corn which is not found in the kernels of white varieties.

RELATION OF CHARACTERS.

One of the purposes of the detailed study of varieties of corn by the Station has been to ascertain what characters of this cereal, being mutually helpful and hence conducive to higher yields, may be expected to be found combined in the same plant or group (varieties) of plants, and what ones, being generally antagonistic to each other, seldom or never occur in the same plant or group of plants. This knowledge is highly essential in the development and improvement of corn, as well as all other agricultural crops; for if one is familiar with these fundamental facts he will be better enabled to originate, improve and select varieties



FIG. 22.—Well-shaped kernels, possessing large, strong, healthy germs.

best suited to his local conditions and purposes in the least period of time and with a minimum of disappointments. As an average of the results of the past eight years' work, supplemented by field observations, the tentative general inferences that follow are made with reference to the varieties of corn studied, when grown under conditions of soil and climate as represented by North Carolina.

ANTAGONISTIC CHARACTERS.

- (1) Earliness in maturity, other things being equal, does not generally tend to large yields of grain and stover nor to high stalks and ears.
- (2) Large-eared varieties usually have a relatively low percentage of

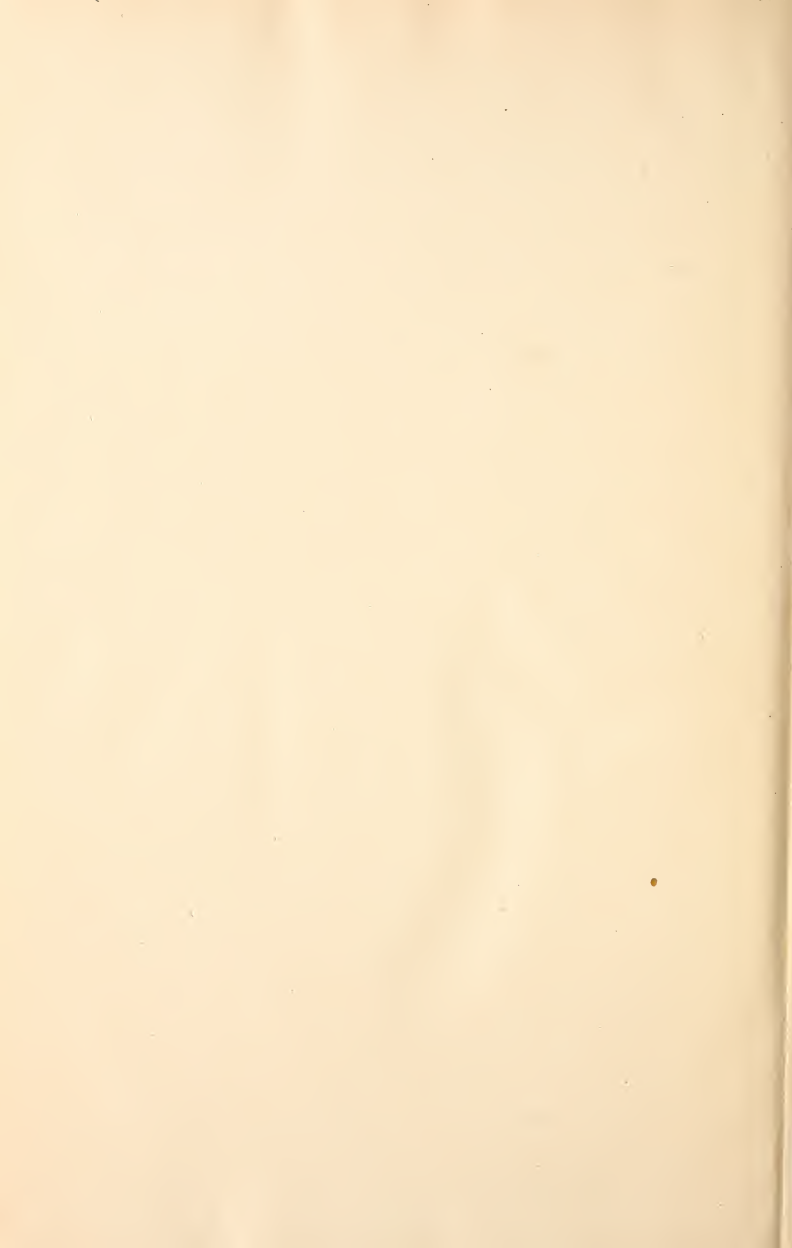
grain to cob, and are, as a rule, less productive of shelled corn per acre, when grown under our conditions. (3) Ears with very small cobs have poorly shaped kernels, as a rule, and give a small amount of shelled corn per ear, and *vice versa*. (4) Kernels of low vitality do not tend to the growth of plants of maximum yields.

ASSOCIATED CHARACTERS.

(1) Earliness, other things being equal, usually tends to high percentage of ear to stover, and conversely, although this ratio is more or less modified by season, soil, fertilization, breeding and selection. (2) Varieties producing two ears per stalk are generally more productive of shelled corn per acre than those bearing only one ear per stalk, although it may be a large one. (3) Medium maturing varieties, in our experiments, have been the ones, generally, to give the largest yields per acre of shelled corn. (4) Small kernels usually possess low vitality, and those kernels with small germs contain a small percentage of fat or oil and reduced feeding value, especially for fattening animals. (5) Varieties with good root and leaf development are usually the most resistant ones to drought and insect and disease ravages. (6) The larger the yield in grain of a variety, the larger the percentage of ear of total plant, the heavier the grain by measure and the less pounds of ear corn is usually required to shell a bushel. (7) The smaller the yield per plant of the same variety, the smaller the number and size of ears and kernels, as well as the number of grain rows within quite narrow limits. (8) The higher the latitude or altitude under which a variety was originated, the larger the percentage the ear is of total plant. (9) Increasing the yield of any variety is attended by an increase in its prolificacy within narrow limits.

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